TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

NIRMAL VIJAYASEKAR

DESIGN AND EVALUATION OF MOBILE TECHNOLOGY IN AGRICULTURE – EMPOWER FARMERS TO GET FAIR PRICE FOR THEIR PRODUCE

Master of Science thesis

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Examiner and topic approved by the Faculty Council of the Faculty of Pervasive Computing on 8th June 2016

ABSTRACT

NIRMAL VIJAYASEKAR: Design and evaluation of mobile technology in agriculture – Empower farmers to get fair price for their produce
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Agriculture is the foundation of human endeavors. It is the basis of human civilization and most of the human activities are based on agriculture. It is also one of the oldest occupations of man. However, it is also often overlooked. Today agriculture is riddled with problems. Scientific research, in an effort to solve the problems, are directed towards agricultural sector. These scientific researched methods and tools reach capable farming communities who can afford it. The agricultural sector is diverse and includes multi-national companies, large landowners and small landholders. Small landholders are farmers who own less than 2 acres of land, produces 80% food consumed in developing countries. Due to limited resources at their disposal, the small farmers are separated from access to resources, tools, and knowledge.

Mobiles phones are fast growing and increasingly becoming cheaper to own and operate. Smartphones have revolutionized our way of living. But due to the limitations in literacy, awareness and high cost of existing services, small-farmers seldom use smartphones to its full potential in agriculture. This limit the usefulness of mobile phones, reducing it to make and receive calls. There is a gap between perceived usefulness and actual use of mobile phones. This leads to small farmers missing out opportunities offered by other markets and are vulnerable to exploitation by middle men. This thesis explores the possibility of creating a mobile service, that can fill in the gap created by illiteracy, cost and availability of reliable information to small farmers.

This thesis proposes a mobile application that farmers can use through smartphones to get agriculture related information through peer-to-peer information sharing. The design for the proposed service will be usable by small farmers with minimum literacy and no prior experience using a smart phone. Additionally, the small farmers are regularly exploited by middle-men due to the farmer's lack of knowledge on the market price information. The need for up-to-date information on crop-price is necessary for small-farmers to get a better price for their produce. The thesis investigate how small-farmers can share information among them regarding market price, so they have a better negotiating capacity. Finally, the thesis explores the user's expectations, needs, farming practices and limitations and presents design recommendations for future work in the topic.

PREFACE

This part of my life has been very eventful. There were crust and trough though out the process. I stated feeling exactly like the agriculturists I was designing for, unappreciated and undervalued. But I had to move on, convincing myself that I am providing some value, however small, to the unfortunate farmers. Working in this thesis gave me first-hand experience on the plight of farming sector. I had to meet the farmers who were reeling under severe draught and crop failure.

To say the least, I learnt much about different research methodologies, choosing one method for a given situation and facing the users for user evaluation.

I would like to thank Dr. Heli Väätäjä for her patience and continuous support. My friends who helped me with their knowledge on agriculture and for helping me recruit participants.

Finally, I thank my parents for supporting me throughout my master's studies. Now it's time to make the world a better place through better user experience.

Let your light shine!

Helsinki, 12.2.2018

Nirmal Vijayasekar

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LIST OF SYMBOLS AND ABBREVIATIONS

TUT	Tampere University of Technology
UX	User Experience
HCD	Human Centered Design
FAO	Food and Agricultural Organisation
ICT	Information and Communication Technology
ROI	Return on Investment
ITCT4D/ICTD	Information and Communication Technology for Development
GDP	Gross Domestic Production
MSP	Minimum Support Price
SC/ST	Scheduled Caste/Scheduled Tribe
UI	User Interface
UX	User Experience
AgriICT	Agricultural ICT program
UNDP	United Nations Development Program
HDI	Human Development Index
DCS	Development Support Center
NGO	Non-Governmental Organisation
MSSRF	MS Swaminathan Research Foundation
RML	Reuters Market Light
HCD	Human-Centered Design
MVP	Minimum Viable Product
TN	Tamil Nadu
IVR	Interactive Voice Response

1. INTRODUCTION

The thesis describes the design, development and evaluation process of an Information and communication technology solution for farmers in India and other developing countries conducted on behalf of the User experience unit of the Department of Pervasive Computing at Tampere University of Technology (TUT). The aim of the project is to design and evaluate a mobile service that cater to the small farmers in India and elsewhere. The design process follows a user centered approach and the primary users of the service are nascent to technology usage and have very little acquaintance with smartphones.

1.1 Background

Agriculture is defined as the science or occupation of cultivating land, rearing crops and livestock [1]. It is one of the man's primary occupation. Agriculture has been the basis of building civilizations. The importance of agriculture cannot be overstated as most of the human activity directly or indirectly rely on agriculture. Humans depend on agriculture not only for food, but also for other essentials like clothing, medicine, and employment. Humanity is always dependent on agriculture for its continued existence. Though we invent a range of technologies, it is agriculture that acts as a linchpin and the human endeavors are tied down in his dependency on agriculture for food. The literary work "tirukkural" captures the essence of agriculture as follows,

"However they roam, the world must follow still the plougher's team;
Though toilsome, culture of the ground as noblest toil esteem." [2]

New technologies have reduced the stress of today's farmers when compared to farmers a century ago. Farming had become easier these days with the advent of machines, farming practices, and knowledge. However, Agriculture today is fraught with a variety of new and evolving problems. To name a few climate changes, water scarcity, land availability and supply chain issues are primary. United Nations project the world population to reach 9.7 billion by 2050 [3] from the current population of 7.4 billion [4]. However, the Arable land that is suitable for agriculture, according to FAO (Food and Agricultural Organization), is projected to increase marginally from 1610 million hectares to 1690 million hectares by 2050 [5]. This is primarily due to the urbanisation, use of agricultural, use of arable land for other actives than farming, land to bio-fuel, cash crops, Industrialization, soil erosion due to poor farming techniques and finally climate change. This has increases the expectation on already burdened agricultural productivity. These factors

have already contributed to the food price spike during 2006-2008 [6] and one can consider this as early warning signs.

This has renewed our interest in agriculture and researchers has already started working on finding ways to improve agricultural productivity and even find alternate and radical methods of farming. Due to increased food insecurity, big corporations are procuring farmlands in developing countries, especially in the sub-Saharan region [7] and are better prepared to face the challenges with the help of funds and resources at their disposal [8]. However, they are not the only entities in the farming sector and it is questionable if the researchers are addressing the farming society as a whole [9]. A major chunk of farm agricultural sector is small farm holders, numbered around 475 million [10] primarily living in the developing countries. Smallholder typically own 2 acres of arable land or less and collectively, they feed one-third of humanity which amounts to 2.4 Billion people in 2016 [8]. Small farm produces accounts for 80% of all the food consumed in the developing countries [8]. Hazell et al [11] describes the 500 million farmers in developing world hold less than 2 hectares of land and amounts to 50% of worlds undernourished population. So, the increase in food grain demand can only be met by increasing the productivity of smallholders. It is only more pertinent to reach out to the communities living in the developing part of the world.

Though the smallholders face a similar problem like their bigger counterparts and corporate farming companies, their problems are only amplified due to the availability of fewer resources like finance, knowledge of latest technology, climate change, and resource plan. There are a variety of approaches, one Agricultural extension services [12] to help small farmers prepare themselves to face the new challenges. This thesis focuses on leveraging the power of smartphones and social network to reach out to farmers and empower them to face challenges and increase their earning capacity.

1.2 ICT for Development

ICT refers to the application of the opportunities and advantages provided by information, communication technologies and the internet toward social, economic and political development aimed particularly towards the marginalized and poor section of the society. It is the use of technology for “development”, “growth” and “progress”.

Mobile phones are at the forefront of Information and Communication Technology for development (ICT for development) [13]. Mobile phones ceased to be a statement of wealth. It has become an inseparable part of people's lives around the world. China and India reached one billion subscribers during 2012 and 2014 respectively. According to Gartner [14], the next development in the mobile sector in India will be in data and internet usage through mobile phones for the purpose of socialization, conducting business

and participating in governance. It is only pertinent to leverage the power of mobile computing for the betterment of humanity in general and in particular the struggling small farming sector.

1.3 Objective

This thesis takes India as a case point and examines the possibility of creating an ICT solution for agricultural and small holder's development. Mobile devices have become essential to our everyday life. The number of mobile devices owned by rural and urban Indians are constantly rising and was projected to stand at 74 million smartphones [15]. By the end of 2016, India has become the second largest smartphone market [16] with a total of 292 million devices. Domestic handset manufacturers have contributed to the increase of smartphone usage by selling high-end phones at a lower price point [17]. Though there is an exponential increase in the number of smartphone owners, much of the potential offered by the devices is largely untapped. This Thesis recognizes this gap and explores the opportunities and benefits in creating an ICT system for farmers using smartphone mobile devices. Further, with the services aimed at smallholders who form the marginalized sections of the community, we are also examining the type of interface that is most suitable for them.

1.4 Structure of the thesis

This thesis follows the motivation and structure outlined here,

Chapter 2 discusses the problem in detail. It touches the cause of the problem and explains the prevalence of the problem. Various aspects of the problem are discussed in detail in this chapter. Finally, the section proposes a solution for that encompasses the problem and opportunities.

Chapter 3 describes the research questions the thesis is trying to answer in order to create AgriICT solution. This chapter also details the research method and design approach chosen to explore the topic of interface for nascent technology users and how to create a successful information sharing platform.

Chapter 4 examines similar mobile application currently in the market and evaluates the usefulness of their features. It notes the usefulness of the features and tries to get inspiration from the existing mobile solutions and research work don on similar topic. This section describes some of the earlier research done on similar topic. This section also analyses mobile application that are similar to AgriICT.

Chapter 5 explains the proposed solution which is AgriICT. It details on the crowdsourcing concept form which AgriICT utilizes for information sourcing. The section then elaborates on some of the challenges AgriICT should face to achieve its objective.

Chapter 6 describes the process stages of development from empathy, define, ideate, prototype, and test of the AgriICT project. A holistic description of the application, its various features, as limitations are provided here. Also, the scope of future development will be outlined in this chapter.

Chapter 7 This Chapter describes the user evaluation methods employed for the purposes of validating the user perspective about the proposed AgriICT design solution. The section describes the case study done in the field for this purpose. It explains the objectives of the study, how the study was conducted, recruiting the participants and finally describes the result of the user evaluation.

Chapter 8 concludes the research and makes suggestions for future research in this topic.

2. ICT FOR DEVELOPMENT – AGRICULTURE

This chapter describes the agricultural sector of India. It provides a detailed view of the problems faced by the agricultural sector. The section further proceeds to elaborate on the opportunities that are created by the problems in the sector. Finally, the section proposes a solution for that encompasses the problem and opportunities.

Agricultural in one of the main sectors that power the economy of most of the countries in the world. India, in particular, is a country that is dependent on agriculture and its dependency on farm-related activity cannot be overstated. Agriculture contributed 20% of the total GDP of India. It employs more than 50% of the population directly or as a support service. It takes enormous effort to move the food produced from the farmers' field to the plates of 1.2 billion population living in various parts of the country [18]. A majority of farmers hold less than two acres of land and continues to shrink due to inheritance laws. The government plays a central role in providing food security to the populace. It also takes the effort of various stakeholder's collective effort in ensuring the continuous supply of food. In order to develop ICT services for farmers, it is necessary to understand the agricultural supply chain process followed in India.

2.1 Agricultural Supply-chain in India

The agricultural sector is primarily occupied by five players, namely farmers, procurement agents, wholesale distributors, retailers and finally consumers. This can change to an extent depending on the crops involved.

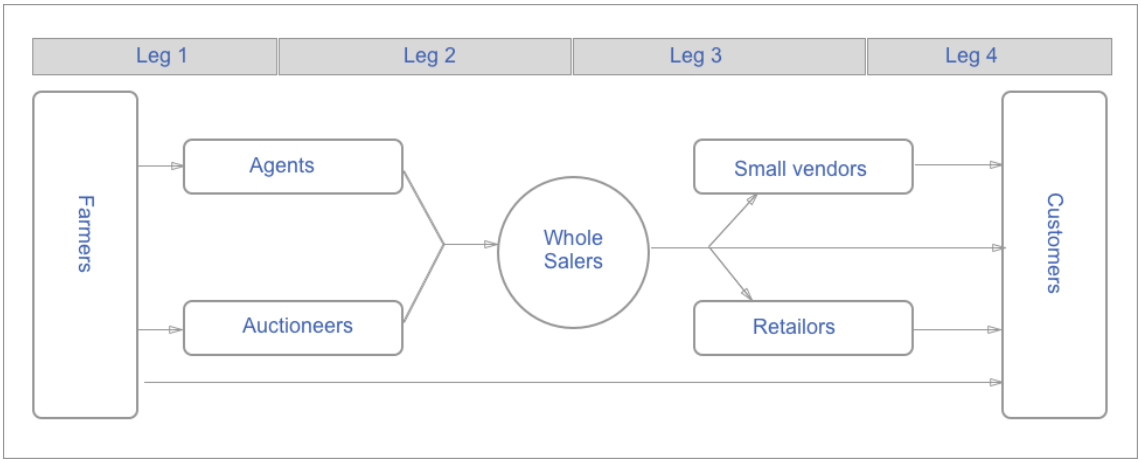

Figure 1 Agricultural supply-chain of food grains [20]

The farmers are the traditional planters and the producers of the farm products. They produce various crops depending on their location, climate, availability of water, finance, return on investment, demand and other socioeconomic reasons. Once the harvest is done

for the season they aggregate their output and transport it to their local market. The local market has agents and auctioneers. The agents and auctioneers deal with a single crop or multiple products at the same time. They procure the products from the farmers. The cost is usually decided through auction. The demand-supply, government minimum support price, and industries dictate the price. The agents then transport the goods to wholesale markets in bigger towns. The wholesale markets are called as mandis. The mandis also provide storage facilities for the goods. Now the whole-sellers procure the goods from the auctioneers. The prices are often different from the prices bought from the farmers. This is due to the increased visibility on the quantity of the particular product. For example, if the particulate season has an exceptional production of mangoes and there are a surplus of mango hitting the market, the price for mango falls drastically. The price difference can be either way, either it can increase or decrease. There is a quite a bit of uncertainty associated with this transaction.

Now the wholesalers buy the stocks from the auctioneers/agents and usually store the goods at their facilities in the mandis. They either own the facility or rent it from the government or the private owners who own the facilities at the mandis. The wholesalers hold the product for over a period of time. Finally, the products are bought by the retailers and small vendors. The consumers usually buy the product from the retailers or the cart vendors.

Since India is an agricultural country, a vast variety of crops are produced throughout the year. The primary crops include Wheat, rice, sugar, fruits, oilseeds and cash crops. These crops provide the calorific requirements of the population and hence are highly regulated by the government. The government provides a minimum support price (MSP) [19] for the mentioned crops. Minimal support price is a standard price stipulated by the government of India to protect the agricultural producers against any steep decrease in farm market price. The government also has well-established warehouse networks around various part of the country and provide storage facilities to the farmers. These food grains are also sold in public distribution ration networks called ration shops.

Figure 2 Typical retail fruit market in Tamil Nadu

Figure 3 Farmer's Market - Retailing produce from small farms

This scene in quiet contrast to the perishable agricultural produce [20] like fruits and vegetables. This produce is always distributed by private individuals and procurement agents. Perishable agricultural products are sold mostly within few kilometers from where it is produced or within the village market. The produce is collected by the collection agent or a middleman and transportation are arranged to bigger cities where it is sold to wholesale and finally to the retailers. The private sellers, including retail shops depend on this route for their supply of non-perishable food grains. The middlemen or the collection agents do not own any storage facility, and are primarily involved in moving the

product from the place of origin to the market also called Mandi [21]. Ideally, the collect a nominal fee of 2-6% of their service. By this way, the production and marketing are intertwined and interdependent. The whole system is intended in such a way that it should be remunerative to producers, cost-effective for markers and continuous supply at a reasonable price point for consumers.

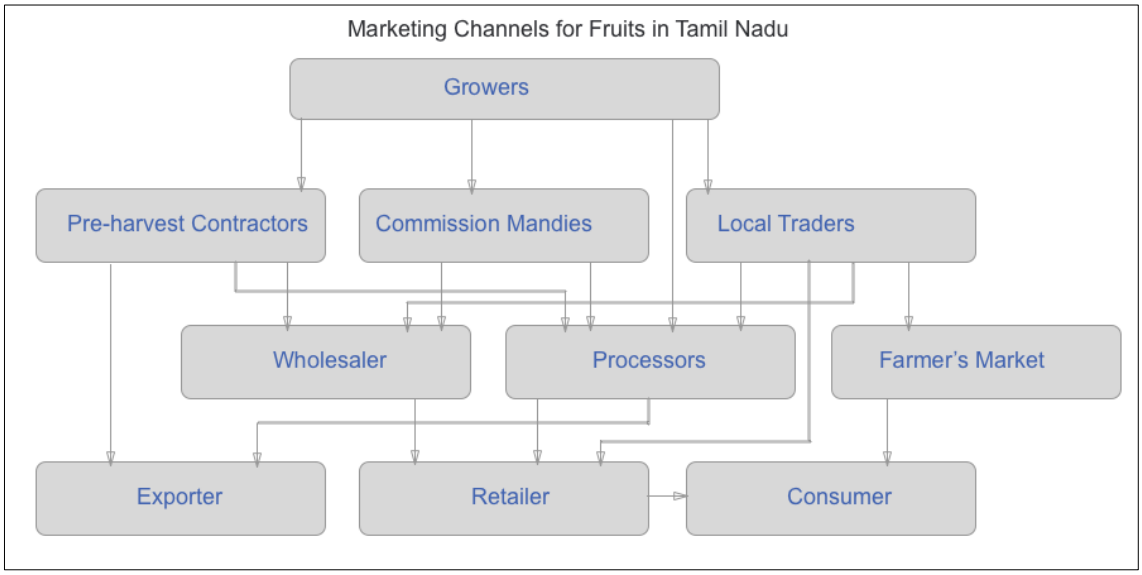

Figure 4 Marketing Channels for fruits in Tamil Nadu [20]

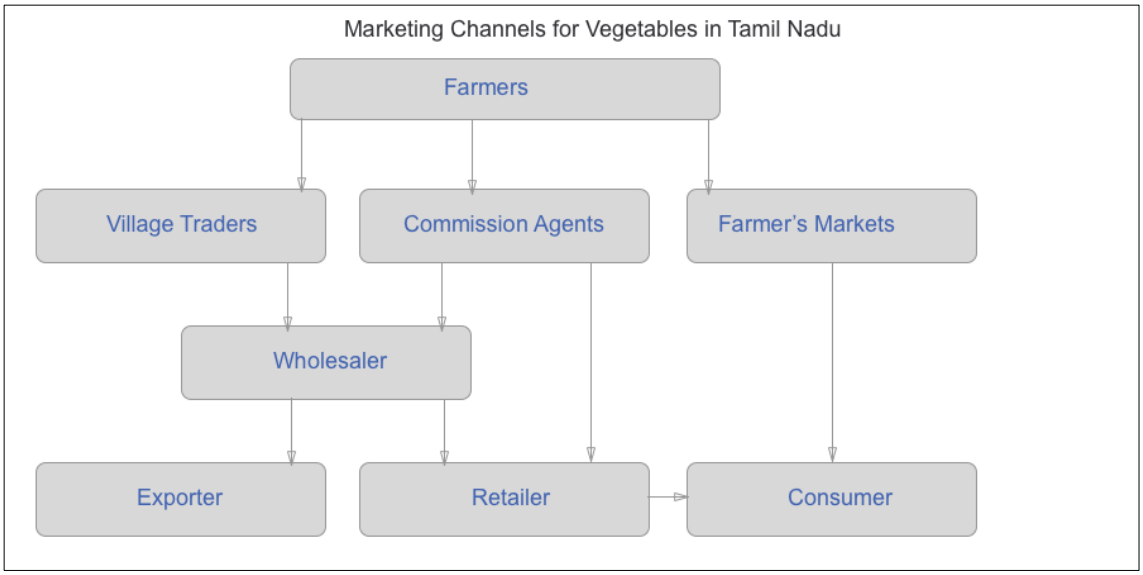

Figure 5 Marketing channels for Vegetables in Tamil Nadu [20]

2.2 Problem

It is important to understand the problems faced by small to create any meaningful solution for the small farmers in their agricultural sector. There are common problems that affect the whole sector and there are problems that affect only the smallholders. Many of

the problems faced by them are due to the availability of limited resources with them. In this section, we try to understand the problems faced by small farmers to come up with a solution that is targeted from small farmers.

Following are some of the problems faced by farmers that can be addressed by an ICT system [11]

- Exploitation by middlemen
- Transportation of products to markets for perishable items
- Small quantity of surpluses available for sales
- Monitory resources for access to irrigation and farm equipment
- Lack of knowledge about product demand and availability
- Climate information
- Lack of price information in city markets
- Theft, wastage due to non-availability of cold storage
- Lack of knowledge of new farming techniques
- Choosing the right crop at the right time, additionally to changing climate
- Market price fluctuations due to oligopolistic nature of market
- Food wastage
- Poor access to finance
- Low levels of formal education and skill

We will consider some of the problems that affect the target audience in more detail in an effort to understand them better to create a worth a worthy solution.

2.2.1 Land fragmentation

Among the host of all problems faced by the farmers, this thesis considers only a hand-picked few that can be addressed by the ICT services that we are trying to design. It would be futile to address some problems, for example, “Finance and loan availability” which is out of the scope of this project. Some of the primary problems faced by the farmers are discussed in this section.

The existing supply chain system is designed to be profitable for all the stakeholders, a lot of is left to desire. Agriculture today is fraught with a number of problems due to inherent problems. As mentioned in the earlier section, agricultural land holding is highly fragmented in India due to inheritance laws. This holding is shrinking further as properties are passed down from one generation to the next. This has left much of farmers on average hold less than 2 acres. Out of the total, 120 million land households in India 98 million people are smallholders. This account has increased from 62% in 1960-61 to 81% in 2002-03 [22]. The average land holding for small farmer stands at 1.42 hectares [23]. This has led to a host of problems in the sector. Due to the sheer number smallholders and

fragmented land, government and its schemes find it difficult to reach out to all the sections of the landholding society.

2.2.2 Middlemen

The role of middlemen and/or collection agents is to procure the farm products from the village. They then transport the products to a bigger market or Mandi and sell it to the wholesale dealers. For this, they mark up the price of the product at around 2.5-6% of the product's original price. They are mainly private individual participants or on some occasion a society. Since they are individuals, they do not possess storage or processing units and transfer the products in a couple of days.

Often the middleman also provides loans to farmers for their production expense. The loan amount will be equivalent to the cultivation of one season and gets accumulated over time. As a result, the farmers become indebted to the middlemen and agents. This forces the farmers to get into advanced sales contracts or sell the products to the agents at a price dictated by the agents themselves. This situation reduces the farmers negotiating power. At present, the small farmers are not in a position to negotiate the price for their produce. They are often forced to sell their products at the price dictated by the middlemen.

2.2.3 Small produce and Transportation

Owing to the limited availability of land with the small farmers only a small quantity of marketable surplus is produced. It is also expensive to arrange for transport from village to town market where there is the scope of better returns for the farmer produce. It is also difficult to transport the crops in bullock carts to city markets. So, the growers sell the product in a nearby village market where there is a surplus of production items and hence further lower selling price.

2.2.4 Lack of knowledge on latest technology

Small farmers are marginalized and have minimal education [24] and are oblivious to the latest technology development in the field of agriculture. About 62.5% of males and a mere 32.5% of the female of rural population are educated and the average years of formal education in a miserly 3.9 when compared to big farmers where the figures are 5.5 while male and female percentage of educated are 73% and 39% respectively. Often tasks that are made easy by the advent of technology is done in traditional way which are less efficient. It is also due to the remoteness of the location of the farm and the farmers themselves are cut off from the rest of the marketing community. Also, even if the farmers are aware of the benefits of new technology, they are not in a position to afford the facilities due to financial constraints. It is highly impossible to buy every new machinery for small farms. However, bigger landowners can have access to such machinery. For example,

Harvesters have reduced the time and labor required from harvesting a given amount of land. But even renting a harvester is not possible for small-land holders.

Figure 6 Typical harvester used in Tamil Nadu [25]

2.2.5 Insufficient resources

Since the farmers are marginalized part of the society they are limited in their reach for resources. For example, access to irrigation is a case in point, though the total area of irrigation has increased. The percentage of small farms under irrigation increased from 51% in 2001-02 to 71% in 2012-13. However, small farmers had to pay for the irrigation while the big landholders had access to cheaper water sources [24]. Also, the participation of women and the socially disadvantaged group as small farmers are increasing substantially. The share of women in rural farming is 83% in 2011. The proportion of scheduled caste (SC) and scheduled tribe (ST) is high when compared to medium or large farmers [26]. However, the quality of land holding is poor in this social group. As this group is traditionally the most marginalized and socially deprived group in India, their access to the market, information, credit, public information and extension services are poor due to the associated social stigmata.

Storage, processing, and warehouse infrastructure facility are also poor for small farmers due to the small quantity of the produce.

2.2.6 Weather

India is a tropical country and is traditionally dependent on the monsoons. Monsoons are seasonal rains and the amount of rainfall it brings vary every year and is extremely

unpredictable. It can bring rain in surplus in a particular year or completely fail and create a drought-like situation. The farmers, small and big alike, are at the mercy of monsoon rainfall. Excess rain can also destroy crops. So far, the seasonal rains remained highly unpredictable. On top of it, the changing weather pattern due to global warming has also started playing a role in the traditional agricultural practices.

Due to the advent of modern weather prediction models, it is easy to predict at least 3 months in advance. However, the weather data are rarely used in the current agricultural practice.

2.3 Opportunities

The problems mentioned in the previous section demands a solution. The problems mentioned in the previous sections are faced mainly by small farmers in India. There is a need for a solution to address the problems. The majority of the problems are caused due to lack of information and the general isolation suffered by the small farmers. Lack of information is due to the availability of up to date information. The farmers depend on newspapers and television for information on crop price and the cost for other related services. These sources provide outdated information and a broader information rather than a localized information. The process fluctuates often and can vary drastically from a city market to a local market. So often the market prices are just indicative and act as a benchmark rather than indicative cost. So, the farmers market the products at an arbitrary cost or accept the cost forced by the middlemen on them. This results in the farmers bearing the loss. Also, most of the middlemen also pin the wastage on the farmers. For example, if the produce weights certain kilograms, about 20% account for wastage and the small farmers have no control over the quantity. This wastage amount is also highly localized and can vary from various markets. Best markets offer minimum wastage and can offer better returns. So, it pays for the information availability, fast and specific, to the farmers.

Secondly, small farmers suffer isolation, socially, economically and physical location of their farms. More often the land of a small farmer is fragmented, split across different location. It can be surrounded by land belonging to other farmers, far from the water source. This reduces the accessibility to their farms and even smaller tasks take enormous effort and the benefit offered by modern technology are nullified. It would be beneficial in such cases to integrate their farm activities and use the power of people networking so that it is a win-win situation for the village community. It is the same for people from nearby villages to form the community.

These factors highlight the necessity for an information sharing and networking platform built especially for the farmers. The farmers have to get necessary information up to date and have to create a network among them. The scope and demand for such a service are huge as there are millions of small farmers around India and the world who feel isolated

and often abandoned by establishments in their respective county. Such a service should help them create and grow network so they can help others and get help from others as well. This would create a mutually beneficial environment and a sense of community for a greater cause.

2.4 Proposed solution

The Need for information is evident from the study of some of the problems faced by the farmers. The majority of the problems faced by the farmers due to the lack of information or miss information and isolation. There is an urgent need for right information at the right time. Traditional methods like newspapers and agricultural research data are slow and are expensive at times. So, there is a gap between the research institutes and farmers where the information is actually used. Also, in the event of a new disease onset, farmers are left to themselves without knowing the solution for it. Small farmers are not in a position to consult specialists to find a remedy. This is due to the remoteness of their location, social isolation or the fear of expenses that might be incurred. In such events, small farmers are at the mercy of big farmers or the village societies and Panchayats. There will also be a situation where farmers are oblivious to trending prices of their crop in a far-off city market or bigger markets outside their village. Arming the farmers with latest price information can place themselves in a position of getting a better price for their products.

This thesis attempts to fill in the gap by creating a service for small farmers. The service should reduce the gap between source if the information and the consumer of the information where it is needed the most. Any service aimed at the benefit of small farmers will be successful and useful if it is easily accessible to them. Because any service that involves a cost will be unpopular among the already poor small farmers. Additionally, it would cost to set up the infrastructure and sustain an information service. This thesis proposes to create a crowdsourced service to source the information from the farmers themselves and share it with their community. With this opportunity in mind, the thesis work proceeds to propose the service “AgriICT” for the small farmers.

3. OBJECTIVE AND METHODOLOGY

This chapter describes the research questions the thesis is trying to answer in order to create AgriICT solution. This chapter also details the research method and design approach chosen to explore the topic of interface for nascent technology users and how to create a successful information sharing platform. This chapter explains the chosen methods and how they contribute to the design activity of AgriICT. The purpose of the activity is to gather requirement for preliminary design from the AgriICT service.

The problems faced by the Agricultural sector in developing countries are vast and diverse. It requires coordinated effort from various public, private and Non-governmental organizations. Considering the resources and timeline of this project, it is necessary to have a SMART (Specific, Measurable, Achievable, Relevant and Time-bound) goals. So, for the purpose of the thesis research, we proceed with investigating the complexities of designing the user interface for nascent technology users new to smartphone usage. The thesis includes the preliminary investigation of issues inherent to user interface design consideration while designing AgriICT which is a smartphone-based application. The focus will be on established issues not yet settled on the design of interfaces and recommendations for future research.

For answering some the research question this thesis plans to follow literature review of the already existing research on the topic. The knowledge acquired will be utilized to create an initial user interface for AgriICT. Following the literature review, field visits will be carried out to validate the data compiled during the literature review. Also, during the field visits, contextual inquiry and user interviews will be conducted for a case study to validate some of the assumptions made in the literature review. By conducting the following work, we can get a deeper insight into the functioning of the farming sector in India. This will help us understand the working culture, problems, and practices followed by marginalized farmers living in the area where the case study will be conducted.

The problems faced by farmers in developing country are multifaceted and require a combined effort from various governmental and non-governmental participants get any meaningful solution. Today's Globalized world economy furthers the problem adds an extra layer of complication. This gets amplified when these problems reach small farmers. Any research targeting the agricultural sector has the potential to easily veer off course, given the complexity of the problem.

So, it is important to define the objective of the research earlier and religiously stick to it. After carefully taking all the problems mentioned in the previous chapters into consideration, and conducting an initial literature review, the thesis identified the following objective of the thesis and research questions the work tries to find answers.

3.1 Objective

To keep the goals of the research SMART, some of the fundamental questions to be considered for the success of AgriICT is taken as the objectives of the thesis. The fundamental goal of AgriICT is to propose a technical solution to aid farmers in decisions making the process as to which crop to choose for a season, so the farmers can get maximum profit for their production. The Service tries to achieve this objective by creating a service that tries to address the following objective.

1. Track market price of agricultural commodities
2. Make crop suggestions for farmers based on climate and market data
3. Track expenses based on seasons, so farmers can make a reasonable estimate when selling the product.
4. Will small farmers be interested to participate in a peer-to-peer information sharing service?

The above-mentioned tasks will be the primary objective of the research. To address the above objective, it is necessary to answer to the research questions mentioned below. In order to gather supportive information to deduce the research questions, we also would like to explore the situations for the following questions

3.1.1 Additional Research questions

Additionally, the research tries to answer the following.

- What combination of content creation and information is more suited/preferred for and by the user – Voice, text or image based?
- How to present (educate) the information to the farmers on pricing
- Why feed farmers with the market price information – negatives of doing that.

We believe answering the research question and the additional supportive research questions will help us better position ourselves to make research propositions based on our findings. This will intern help us make informed design decisions and the necessary functionalities when included in the AgriICT, can benefit and positively contribute to the small farming community.

3.2 Research

An initial literature review conducted on existing research on the topic agricultural exchange service and ICT service for developing economies. Through the data collected from the preliminary literature review, the research made an assumption on some of the

main services to be provided by the proposed solution. Some of the features planned to be included in the initial UI, but not limited to are mentioned below.

- Crop price
- Market information
- Latest technology development
- Weather
- Government scheme Information

3.2.1 Research Methodology

After finalizing the research questions, the research work continued with literature review. The purpose of conducting the literature review is to establish the theoretical frameworks involved in solving the given problem, namely crowdsourcing, Information and communication technology for development and design for illiterate users. Given the diverse scope of the research question, it is important to consider some of the findings made in the previous studies related to the topic.

With the data gathered from the literature review an, the research proceeded with designing the initial user interface. This is due to the physical location of the research and the actual users.

3.2.2 Literature Review

The primary purpose of any research is to conduct creative and systematic work to increase the collective knowledge of humans, culture, and society, thereby creating new purpose for the gained knowledge [27]. In the light of latest development in communication technology, comprising elements like smartphones and high-speed networking, crowdsourcing has become an important topic of study. In order to tap the opportunities provided by “the next billion” [28], the technology industry has their focus on developing countries. “The next billion” refers to the people in the developing world who were left out in the earlier internet growth due to the peoples socioeconomic and literacy reasons. So, like crowdsourcing, technology for illiterate users have received focus from the research community. It is important to utilize some of the present knowledge on these topics and continue further research from there. The literature review for this project was conducted initially to gather existing knowledge on information and communication technology for development and designing for illiterate users.

The literature review is conducted to gather deeper insights on a given topic. It provides the researcher the knowledge and ideas that are already established in the research are and the strengths and weakness of the idea. Establishing the strength and the weakness of any given research will provide researchers with ideas and direction to proceed further

with the topic. The literature review also presents rework on a given topic and helps new research build on top of the existing work on the topic. The literature review also helps in narrowing the research problem. So naturally, the thesis started with the literature review. Some of the works that are examined in the literature review are elaborated in the next section.

The thesis work proceeded to conduct further literature review of the existing research after finalizing the objective of the thesis defined during the initial literature review. The literature review was conducted with the objective in mind. Relevant works done on the fields defined in the thesis are collected methodologically. A thorough study on the collected research works was conducted to gather all the relevant information that can be used for the purpose of this thesis. The collected data were then assessed for their usefulness with regard to our thesis and combined with an order. For example, research information on how to design a successful ICT program the people can use without external stimuli, design considerations for illiterate users and earlier ICT projects are outlined in the next section.

The data collected through the literature review provided will initial design consideration. With this design considerations, the thesis work proceeded further by creating an initial low-fidelity prototype. The low-fidelity prototype was converted to a paper prototype and was used to conduct a filed user testing.

3.2.3 Case study

The thesis furthered by conducting a case study of the field followed by the user testing. Case study facilitates an in-depth study of a specific research problem rather than a general statistical survey, which can be used for building a large-scale application. It is necessary to know the expectation of the users of a service like AgriICT for the initial design phase. It is important to narrow down from a broad scope of research into more specific researchable samples. The case study also helps us in testing how a specific research idea applies to the realities of the real world. A case study for the purpose of this thesis examined the research idea that “farmers are ready to network among themselves and are willing to contribute their expertise to the service”. A Case study is suitable for this given situation as not much of a research has been done on the field of crowdsourcing by illiterate farmers.

How case study can contribute to the thesis. The case study can help us understand a complex social issue by creating a detailed contextual analysis of events and their relationship. It gives the researcher the freedom to employ multiple user research methods to investigate the research problem at hand, in our case we used user testing to evaluate the user's mind map and expectation. It was also chosen as an evaluation method to validate some of the assumptions made during the literature review. This is important due to the

fact that some earlier researchers were conducted in urban settings while the primary users of service are rural users. The cultural aspect of different regions in India also plays a critical role in how the users perceive technology. Also, in a social setting, it is important to understand how any proposed service can be accommodated in the user's everyday contextual settings. This can help us understand the motivation that encourages the user to participate in the service and how it can limit his participation. It can also help us understand how the user's social interaction can help him use the service.

For the above-mentioned benefits, the thesis considers employing the case study method valuable for the purpose of research for this thesis.

3.2.4 User Testing

The user testing was conducted as part of the case studies that were conducted in the field with real users. A user testing was essential for this thesis to validate the design information gathered through the literature review. The user knowledge can vary due to the different cultural setting, even if the research was conducted within India. Some of the earlier research works were conducted in urban settings where the participants are more exposed to technology. This sample set of users can bring in prior experience with technology, however, limited, and can affect the results positively. So, it was necessary to conduct a limited user testing in the rural background were AgriICT will be used primarily.

4. LITERATURE REVIEW

This section describes some of the earlier research done on similar topic. This section also analyses mobile application that are similar to AgriICT.

ICT is a powerful tool at our disposal to tackle long-standing problems of humanity. ICT has proved its worth time and again in different locations and settings. It requires careful planning to design ICT that fits different problem scenarios. But the underlying concept is just same with various services that ICT can offer. Some of the successful implementations are mentioned here.

4.1.1 ICT – Reason for Success or Failure

In welfare, agency and 'ICT for development', Aishwarya Lakshmi rattan and Savita Bailur attempt to trace the definition of Development. It is important to explain the term development in "ICT for development". It is necessary to understand, theorize and learn from the discrepancies that often arise between the intention and usage of ICTD projects. Development as a discipline is often attributed to Harry Truman's speech in 1949 [32] [33]. Later, During the 1960's and 70's the definition of development exclusive to the economic perspective expanded to the social aspects. As a result, the United Nations Development Program (UNDP) devised Human Development Index (HDI) in the late 1980's. Revision during the 90's described development as a biological concept and post-developmentalists argued that 'development' was something being done to people rather than involving them. So, what is development after all? According to Nobel laureate Amartya Sen's approach, socioeconomic development should be viewed not in terms of a lack of specific "endowments" but is "unfreedom" to achieve certain "entitlements"[34], "He goes beyond the income-based metrics in saying that improve each individual's capability to live a better life must be viewed as both the means and the end of development and is achieved through complementary State and market activity. As a result, improving capabilities often involves ensuring that the person has the freedom of opportunity to pursue the option of their choice, as well as the freedom of process to make his own choice as well as the freedom of process" [34].

Now that the meaning of the term 'development' is defined in the periphery, we can understand how are successful projects are implemented through information and communication technology for development. It is important to establish the success criteria for any ICT project. The paper examines (A) how do "ICT for development" projects enhance the capabilities of users and (B) how does the implementation of an ICTD project come to be a constant social choice between providers and users [34]. To illustrate the conflict between welfare and agency inherent in the response to the above questions, the

research forms a simple two-person game between a symbolic ‘user’ and ‘provider’ to find the optimal developmental outcome of the game that benefits the ‘user’. The research uses the game theory to make the following conclusions [34].

- Collective choices between provider and users with varying ideas on desired capabilities leads to divergent social choices around the use of ICT artifact for ‘development’.
- The suboptimal development outcome may manifest when a strict (paternalistic) provider mandates that the user should use the ICT artifact strictly for the welfare-related application.
- Suboptimal development outcome will manifest if the user uses the ICT artifact only for entertainment-related application.
- User’s capabilities are subject to change on a social, structural and behavioral context when factors involving usage delivery y_f (positive utility in the future) is greater than usage deliver y_e (positive utility in the present).

The research paper establishes that the users and the welfare agency benefits if and only if the welfare agency follows a non-paternalistic approach and the user realized the benefits they can achieve from an ICT project. Users should concentrate on long-term goals rather than short-term benefits.

4.1.2 Avaaj Otalo – IVR based ICT service

Avaaj Otalo is a field study of an interactive voice forum for small farmers in rural India by Neil Patel et al [35]. Avaaj Otalo is a forum for asking questions and browsing other farmers question and responding to a range of agricultural topics. The research documents the flow of information and participation by 51 farmers in Gujarat, India. It was designed as a feedback loop for a radio program in Gujarat were DCS (Development support center, NGO Ahmedabad), the creators of the service, can effectively respond to questions and suggestion. Avaaj was designed after an interview with farmers, agricultural experts, DSC management and staffs and other stakeholders.

The system is a voice-based service accessible through the mobile phones as most of the farmers had access to mobile phone. Their research also found that the farmers were comfortable with the simple IVR application. The initial features included in the service were Question and answer forum, Announcement board, Radio Archives. Avaaj otalo implemented a Voice Site using IBM Research’s Spoken Web platform.

The service was then tested among 51 farmers on a pilot basis. The farmers used Avaaj to listen to other farmers. Their primary interest was to listen to other farmers talk about new crop disease and pests. They wanted to be better prepared to face the new challenges and threats. Among the 51 users, top 10 users accounted for 80% of overall call, with top

3 callers accounted for 60% of calls. The response to the questions came from other farmers and agricultural specialists at DSC who regularly monitored the forum. As a social norm, the farmers themselves started regulating the questions. They refrained from asking the same question again and questions whose answer can be found in the DSC newsletter. The core user who accounted for more than 80% of all the traffic to Avaaj were with limited education. The three top users hadn't graduated past 10^{th} grade. However, it should be noted that the top users were young farmers, all under 30 years of age and were progressive and experimental in their agricultural practice. The lack of an alternative reliable source of information made the pilot users value Avaaj service.

However, Avaaj was also used for other unintended purpose. Some users used Avaaj for entertainment, business consulting and advertisement purpose. Avaaj otalo serves as a blueprint for AgriICT and learnings relating to repeated usage, misuses (using the service for unintended purpose), and benefits of the service like Avaaj otalo can be utilized for designing AgriICT service.

4.1.3 Designing for semi-literates

About 781 million of the world population over 15 years of age are illiterate of which 496 million are women. Women's contribution socially and economically in the development of a household is immense. However, illiteracy has placed them in a disadvantageous position in accessing technology. Including extra devices like keyboard, microphone, speaker adds complexity and cost to the existing scheme. Speech-based UI is often suggested as a solution to overcome barriers pertaining to illiteracy and cost. The research paper "A spoken dialog system for rural India: Tamil Nadu" by Madelaine Plauche and Madhu Prabaker deals with a speech-based user interface for illiterate and semi-literate users in Tamil Nadu, India. Reliable evidence indicates that access to written information increases farmer's productivity and earning potential [36][37]. The speech-based user interface with all its advantage is often tricky to implement because of challenges like dialects, multilingualism, and cultural diversity. Also included is the fact that illiterate people and their interaction with technology are often poorly understood by researchers [38][39].

Available previous UI research targeting illiterate people in focus on teaching literacy skills [40] and require some amount of training and memorization of icons by the users which adds to the cognitive load. Using local language will be advantageous and the user can bank on their existing knowledge in their language.

The service Tamil Market provides crop price for top ten crops, weather update and rainwater collection technique using voice-based user interface. The voice commands are primarily 'Yes' and 'No' answers to minimize errors that arise due to different dialects and accents. Tamil market sources information from the MS Swaminathan Research Foundation (MSSRF) a non-governmental organization for the social and economic development of the rural poor of Tamil Nadu. Tamil Market proceeds to conduct a pilot study with 13

users, both men and women between the ages 28 to 60 years. It was observed that most users were able to complete the task assigned to them, but had difficulty understanding the nature of the 'tasks'. Illiterate users who have never attended any form of formal education refused to participate in the usability test due to an aversion to technology. Interest in Tamil Market correlated with the distance of their village from the nearest market. The overall observation verifies the potential for a speech-based service in developing regions which is a positive observation.

Another research article "Text-Free User Interface for Illiterate and Semi-Illiterate Users" describes the process of designing user interface for illiterate and semi-literate users of semi-urban settings. The research describes their work towards creating User Interface for illiterate uses where they can interact with the system on minimum intervention from any external participant. The ethnographic design was done in the community in and around Bangalore, Karnataka. The research built two applications, one a Job search for domestic laborers and a generic map navigation system to navigate the city. The research describes the design process, design principals and final application design results from user testing. The results indicate the preference of text free design over standard text-based designs and the potential to bring complex computer function to the reach of illiterate users.

The biggest challenge while following an Ethnographic UI Design approach was accepted as a part of the community, make the users comfortable to talk and extracting relevant information from them and help them overcome the fear and aversions using any technology. The ethnographic study revealed that the users recognized semiabstract cartoons and more photorealistic graphics much better than complex abstract art. The user was quick to adopt when the simple icons like arrows were replaced with the skeuomorphic icons. The research also proved earlier assumptions that the illiterate users have difficulty using technology support instruments like a mouse, stylus and were hesitant to operate them out of hesitation that they might spoil the instruments. Towards the end of the ethnographic study, the users fundamentally doubted that the technology can deliver the service they are interested in. As such, they experienced barriers beyond illiteracy while dealing with technology, which included "lack of awareness of what a PC could deliver, fear and mistrust of the technology and lack of comprehension about how information relevant to them was embedded in the PC" (Text free User Interface for illiterate and Semiliterate Users.) [41]

4.1.4 Competitive Analysis – MyRML, Kisan Suividha

MyRML is an online mobile based ICT service introduced by Reuters Market light. This Mumbai based RML ICT service provides timely, unbiased, localized and accurate information on crop price, new government schemes, subsidies, the source of finance, weather and crop advisory, and personalized information service with opportunities for easy purchase. RML aims at enabling farmer's lower costs, increase yields and make an informed

decision about their farming practice. It is an SMS based on demand service providing information for farmers across 18 Indian states and 9 languages on a daily basis. It employs people in its service and has customer support services. RML offers its service for paid subscription ranging from 2 years to 1 month. The farmers can use Nationalized banks to pay and update their membership. They can subscribe to their suitable crop to get price alerts and has to call customer support to change or add a different crop to their subscription.

"MyRML provides life cycle information at every stage of the crop development. Presowing to harvest, giving information on market price, weather, local and regional agricultural new and crop advisory till selling the crops. In additions, it provides district-level trade information, daily updated audio agricultural news on RML Vani and detailed farming, information on the library for selected crops" [42].

MyRML provides the market price of subscribed crops. A particular farmer can subscribe two crops at any given time. He gets the crop price from nearby markets and sellers. It also gives the recent historical price of the crop he has subscribed to and check the trending patterns for the price.

Secondly, the farmers' area weather detail is updated to the farmers. The details are comparable to general weather applications. The news bulletin provides the farmer's update on the latest news related to agriculture. Alerts are also provided to farmers on important news that has a high impact on farmers. The farmers themselves can provide suggestions to the MyRML team about shortfalls and improvements that can be made to the service. There is a catalog all the possible crops that the farmer can subscribe to. The farmers can search for the crops available in the catalog and change it themselves or contact customer service center to get updates for new crops.

Finally, the farmers can post questions in the form of text and images to get detailed answers from experts employed at MyRML. This provides an opportunity for farmers to post questions regarding their crop and diseases that affect their crops by sending the image of the diseased crops.

It is important to know the basic difference between AgriICT and MyRML. MyRML is a paid service and requires dedicated infrastructure to maintain the service. The farmers should pay for the service. The subscription charge for RML are 24 months- Rupees (Rs) 900/-; 12 months- Rs 450/-; 4 months – Rs 350/-; 1 month- Rs 99/-. The charges are nominal from a farmer with a substantial income. Farmers with more than 5 Acres of land will have constant income from Agricultural source. Fringe farmers and small farmers who own very meager amount of land does not have a constant source of income and are often dependent on loans from local money lenders or the middlemen themselves. For them, paying the subscription amount for a season of 6 months or a continuous subscription of twenty-four months is an expensive process and the farmer can loose interest in

the service. AgriICT plans to remove the back-office process, thereby eliminating the support staffs. Instead, the AgriICT will be crowdsourced and will source information from the agricultural stakeholders and the people in the know. AgriICT will source information from other farmers, Marketers in nearby markets and agricultural product sellers. By this way, we can keep the cost at a minimum and provide the service at free of cost.

How AgriICT exceeds MyRML. With the eventual use of the AgriICT app by a significant number of the user, we can create a map of different crops that are grown in a particular region. With this information, AgriICT can predict the demand-supply of crops in particular regions and in central markets. During the later stages of development, we can implement crop suggestions successfully for farmers to maximize their return on investment.

Kisan Suvidha is an android application sponsored by the government of India. The User has to register for the application using his location and mobile number. The application provides information on the market price of crops from nearby markets. It also provides market prices for related products like fertilizers. However, the price of the crops mentioned are legacy information. Information are not up to date and does not reflect market trends. So, there value it provides farmers are limited and they use the pricing information as baseline reference and not absolute value.

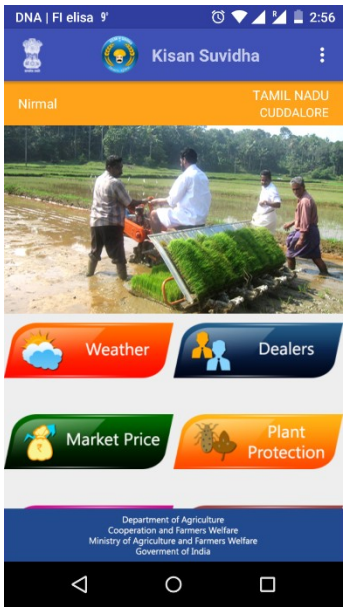

Figure 7 Kisan Suvidha

5. SOLUTION - AgriICT SERVICE

This chapter explains the proposed solution which is AgriICT. It details on the crowdsourcing concept form which AgriICT utilizes for information sourcing. The section then elaborates on some of the challenges AgriICT should face to achieve its objective.

5.1 AgriICT

This thesis propses AgriICT services as a solution to some of the issues faced by the agricultural sector in the developing world. What is AgriICT? AgriICT is an information sharing platform for farmers. AgriICT is intended to be a place where farmers and agriculture oriented sector professionals can share knowledge among themselves. It will be a platform where agriculturalist can ask questions related to their farm activity and get answers from anyone in their sector. This service is aimed at empowering farmers to learn from each other and better understand their sector so they can benefit collectively as a society. By connecting the people of the agricultural sector, the service aims at creating a sense of community among the marginal small farmers and reassure them that they are not alone. Information sharing will increase the societies collective knowledge so it can be better at problem-solving, stimulate innovation and reduce loss due to lack of information.

AgriICT also creating long-term values like reducing redundant effort by solving a problem collectively, reuse ideas that work best, learn from others experience, create an effective process in agriculture, share resources and take advantage of the existing expertise and knowledge of the field leaders.

AgriICT project aims at reducing this gap and provide information to farmers at an individual level. Farmers can subscribe to the crops that they are planning on a particular season or planning to cultivate in the future. Following are some of the information the farmers can get through AgriICT in the preliminary design implementation. They are as follows.

- Crop price based on location
- Crop suggestion based on location
- Market information on trends
- Latest technology development
- Weather and alerts
- Government scheme Information
- Track operational expenses

The information that is required to be fed to the farmers are often scattered and it would be expensive to source. It requires constant work from a large number people and man hours to gather the information. It would require an organizational effort and sponsors to build such a service. Even if a Non-profit organization or governmental committee takes up the challenge, the organization must pay for the infrastructure, human resources, and network needs. This expense will be incurred year on year and impossible for organizations to sustain operations and will fail eventually. On the other side, even if the service demands a nominal fee, it would never become popular among the marginalized farmers.

5.2 Crowdsourcing Information

The solution is to build a self-sustaining service design that relies on the users themselves for the required information. Crowdsourcing is one solution for this situation. Crowdsource enlists the service of a large number of people, paid or unpaid, over the network. The participants can share and receive information known and unknown to them.

5.2.1 Crowdsourcing

The 'crowdsourcing' was defined by Jeff Howe and Mark Robinson in a magazine in June 2006. Jeff Howe defined it as ‘the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call’ [29].Later the monitory part was added to differentiate it from the wiki format of knowledge sharing.

Crowdsourcing works by organization identifying the tasks done in-house. Then the organization recruits a crowd of outsiders and outsources the task. Anyone interested in the task can participate in the task. The best solution to the task is selected and the payment is made for that worker. The was made possible by the advent of web 2.0. This has reduced time, cost and effort of recruiting the talents permanently for the organization but still can get the best talents in the society for the given task [30].

AgriICT is a crowdsourced, Location-based social message board where farmers can ask questions about their crop in an open forum of other farmers, marketers, researchers, and individuals who are willing to help farmers. AgriICT plans to connect two or more individual farmers to network and share information they have with them. AgriICT also plans to connect farmers with agricultural researchers, marketers with farmers in this way. In this way, farmers get quick and customized information as and when required. Farmers can also get price information from nearby markets and other desired markets, so they can get a better deal for their produces. This will also enable them to find new markets for their produces apart. As the user base increases, it will enable to match demand and

supply otherwise will remain hidden in the vast plains of the agricultural landscape. The planned service can act as a new channel for information to farmers. Creating connected farmers can have the additional benefit of connected farmers. More farmers can collaborate and rent machinery and arrange for transport to bigger markets.

Figure 8 Typical small farmers selling produce in farmer's market in TN, India.

AgriICT can aggregate some of the available information and suggest farmers' crops that can provide an optimal return for a particular season. This can be achieved by increasing the visibility of crops planted in that locality, market price, water availability and demand-supply trend in nearby markets for that season. Return on investment will be increased.

The system can provide weather updates to farmers and inform them of the availability of water for that season. Apart from the usual weather applications AgriICT can push warning of upcoming flood or warn earlier the drought conditions so the farmers can plan their activities well in advance and mitigate risks in advance

AgriICT will also help farmers track their expenses for the season so the farmers can know what their capital expense and ongoing expense are. This way we can enable the farmers to calculate a fair price for their crops

Price and Market information. The Agricultural crop prices fluctuate vastly due to a variety of reasons. Unseasonal rains, overproduction, increase or decrease in demand supply and crop quality or diseases. This may cause surpluses in the market or fail to meet the demand. AgriICT will provide information on the trending market price of crops the farmers are interested in. This will enable farmers to plan their activities better and mitigate the risks better. The app will let him decide on crops that will provide the maximum benefit of a given season by showing him the trending price.

Government information and new technology info. Government disseminates information about new technology through print media and television. These media are slow and reach all the recipients with considerable delays. Often the information is outdated when it reaches the intended user. Most often many isolated farmers lose out on government schemes, subsidized sales, subsidies, and disaster relief due to lack of information or information reaching them after deadlines. So, in such scenario, being connected through AgriICT like service will reduce the instance of farmers missing out welfare schemes.

New researchers and findings often originate from universities and research institutes. The new findings like treatment to a new crop epidemic, pest control always disseminates through farm helplines and agricultural societies. Small farmers isolated due to social stigmata or the remoteness of their location miss out on the new treatment methods. They often get the information on treatment after the damage is already done. So, information on new treatment methods can reach farmers faster through the help of service like AgriICT and effectively prevent farmers incurring losses.

Even though there are a number of benefits for a networking service, there is no instance of a similar successful networking information service. This is due to most of the existing service are paid and operate on “service on demand” model. Any paid service will fail due to the fact that the indented users cannot pay for such service. So, without a substantial user base, such service becomes more expensive to continue operation and operate at a loss. This causes the service to stop its function.

There are also other factors that make such a service unpopular in today’s digital environment. The social and geographic status of a country also offers huge challenges to such a service. Countries like India, China, and Nigeria which are classified as developing countries are huge in population, land mass and cultural diversity and can offer a variety of challenges to a service like AgriICT.

So, it is necessary to take the challenges into consideration while designing a service for larger markets like India, China, Nigeria and elsewhere. The challenges faced when designing a solution for a larger audience can be diverse and found across the population. It can be best described as social and economic in nature. Some of the challenges are discussed in detail in this section.

5.3 Challenges

The challenge can be as simple as motivation for user participation in cultural complexities. Some of the mitigated complexity for the purpose of this thesis are user literacy, smartphone penetration, network availability, user motivation, technology availability, the challenge of content creation, motivation and diversity of local languages with its different dialect.

However, there are several challenges that must be taken into consideration to successfully implement the design. Some are technological hurdles and others are inherent to users of the system.

5.3.1 Technology Availability

The small farm holders are late adopters of technology and in most cases, use the old push button mobile phones for communication. In such cases, the service may not be accessible from their devices. The service may be incompatible with their mobile phones are will require the users to upgrade their mobile phone. So, the users must be convinced of the benefits they may get from the service. They should believe that they get a good return on investment they are making to buy a smartphone. Also, from the developer perspective, the application should be accessible from a low-end smartphone with reasonable memory and processing capacity so that the farmers are not forced to buy the costlier smartphone.

5.3.2 Network

The modernization of mobile network and competition among the operators has provided a reasonable network coverage in India. On the other hand, Network penetration is low in rural India. There are places that are not properly connected to a mobile network. Internet coverage is still in its infancy in India and high-speed 2g/3g connections are non-existent outside of the urban centers (As of 2016). The service designers should take into consideration the availability of internet connection and its speed and design a lightweight application. The application should be stingy with the amount of data it receives and sends. By this way, more user can independently use the application on their device and will recommend to their peers. The mobile internet scenario is fast changing in India due to the competition among the network operators. This competition has drastically reduced the cost of internet and connection speed. 4G networks have become commonplace, and provide at a very low cost. One network operator provides 1GB of 4G data per day for Rs.300 for 3 months ($4.5 for 3 months). This has forced other operators to follow suit and brought 4G internet within reach for smallholders. Given the uncertain scenario in the mobile internet pricing, it is advantageous to design a lightweight application.

5.3.3 Infrastructure Availability

AgriICT is data dependent as it supplies up to date information for smallholders. The market price is scattered and across a vast region. It fluctuates frequently throughout a period. During certain seasons, the price of certain crops can vary drastically with hours and intra-day changes are significant. It is not economically viable to employ people to gather pricing information. The service should be more crowdsourced to gather infor-

mation. Smallholders, merchants, agricultural market societies participation will contribute to the data collection. Also, recording the historic price is a huge task and can confuse an advanced smart-phone user due to the magnitude of the data. So, it is important to take into consideration, the limited experience of small-farmers with the smart-phone usage and simplify the data presentation.

5.3.4 Motivation

Small farmers get pricing information from the service. He gets pricing information from all nearby markets, thereby he can get the best price for his produce. He can also know if any other small farmers near to him require transport, so they can combine their resources to transport their produce, reducing the cost of transport and increase profit margin. It is also important that every participant of the service must contribute to the service as and when he can. The users should be made aware that it is not only a platform to receive help but also offer assistance to others who are in need. By this way, the farmer will realize that he is not receiving assistance for free, but also, he is responsible for assisting others. This give and take will help create a sense of ownership among the participants and they are working toward a common cause which is the motivation to participate in AgriICT like service.

Merchants can use the platform to market their goods. For example, if a group of small farmers requires fertilizer or pesticide, the marketer can directly contact the group to sell his product. By this way, the marketers can find new customers, and this can motivate the merchants to contribute to the service. Additionally, the researcher can also get data and crop information on yield, new disease and response to new treatment methods from AgriICT like service in real time. This will contribute to their research activity and they can get information faster and cheaper than them visiting the fields to gather data. This will reduce their time and effort spent on gathering data which can be spent on more productive work. This way the relationship between the users and service will be symbiotic and will motivate all the stakeholders to participate in a service like AgriICT.

5.3.5 Problems with Speech Interface

India is a vast country with 18 official languages. Each language, in turn, has hundreds of dialects. It takes enormous effort to research and implement a voice-based speech interface. The speech interface has to interpret and understand the spoken language give the diversity in the spoken language. To create a content creation system, we should understand these differences and as well as take the accents into consideration. It requires huge effort to research and design a system that can be used across a vast country like India. Any system that chooses few regions will be limited in its access and lose on the economy of scale a country like India can offer. So, speech interface may not be suitable for a

system like AgriICT at the early stages of research. Its utility can be explored in the advanced stages of the product life cycle where there will be substantial user base and funds in the form of sponsors from government and non-governmental institutes.

5.3.6 Literacy

Literacy is a challenge, particularly in the rural population. The urban literacy rate is 84.1 million as of 2011 [31]. On the contrary, the rural literacy is 67.8%. It dips further to 58.75% among rural woman. This forms the main issue in creating a service of the smallholders. The Smallholders often have minimum education and are not capable of reading and writing in the native language and English which is often used in mobile devices. The mobile usage among rural population is high but limited to attending the call and receiving calls. They often store the number on a piece of paper or dial from the recent calls. The education factor is important when designing service like AgriICT. So, it is important to understand the limitation caused by minimal education on designing a crowdsourced service which expects the user create and consume information and content with minimal external support. The rest of the thesis investigates on how to create an interface that is effective, efficient and satisfying for smallholders.

6. DESIGN

This chapter describes the process stages of development, and test of the AgriICT project. A holistic description of the application, its various features, as limitations are provided here. Also, the scope of future development will be outlined in this chapter.

The development of AgriICT mobile application is an iterative process with several phased of designing. It also follows a Hypothetical design approach. The initiations of the project are to find the needs and wants of the farmers in developing part of the world. This is followed by creating a service that addresses some of the core issues that the farmers face. Thirdly, it is tasked to create a service that is usable by the illiterate and semi-literate users to their benefit. Additional to usability, service is aimed to be crowdsourced, and so it is important to identify how to motivate various stakeholders participating in the service. Subsequently, create a prototype and iterate on the design with respect to the existing research done on the field. Finally, Test the prototype with the users by conducting field interviews and gathering their feedback. The project ends with feedback and recommendations for future research on the subject.

6.1 Initial UI design

The preliminary studies started with the idea of creating a technology support study for farmers using mobile services. The ubiquity of mobile phones in developing countries and elsewhere prompted us to use it for the betterment the underprivileged. The research started with initial studies mainly work done by Neil Patel, Indrani Medhi et al. The project Avaaj Otalo outlines the use of Radio communication for the benefit of farmers in Gujarat, India. Discussions with supervisors helped substantially to focus on the problem since the problem of farmers in developing countries is vast and requires enormous effort from multiple governmental, Non-governmental and grassroots organizations. Discussions with Researchers from Agricultural University, Coimbatore, India, helped us zero on a fixed problem which is small farmers in India are not in a position to get a fair price for their agricultural produce. They are forced to accept the price dictated by middlemen

The problem of middlemen is faced omnipotent by all farmers in developing countries. So, we tried to leverage the power of mobile to mitigate the problem of middlemen. The root cause of the problem was the lack of information between farmers and the fragmented structure of landholding in India and elsewhere. Mobile phones act as a medium through which information is exchanged. The information lies separated by distance and an average farmer cannot know in person every source of information. AgriICT will act as a medium to connect two unknown users so they can share their information. With

available data, AgriICT will also provide crop suggestion to farmers to maximize the profit.

With this in mind, we proceeded to create a mobile application based on the Android platform. Android platform was chosen project, given its market share in rural India and its capacity of powering budget and lower end mobile phones. Android phones are available in cost-effective smartphones and have become a symbol of the rural market.

6.1.1 Human-Centered Design Approach

This project, as it aims to reach the poor population of India, follows Human-centered design (Human-centered design) approach to the design process. HCD starts with users and end with users and is based on empathy and understanding of the user.

Empathy > Define > Ideate > Prototype > Test

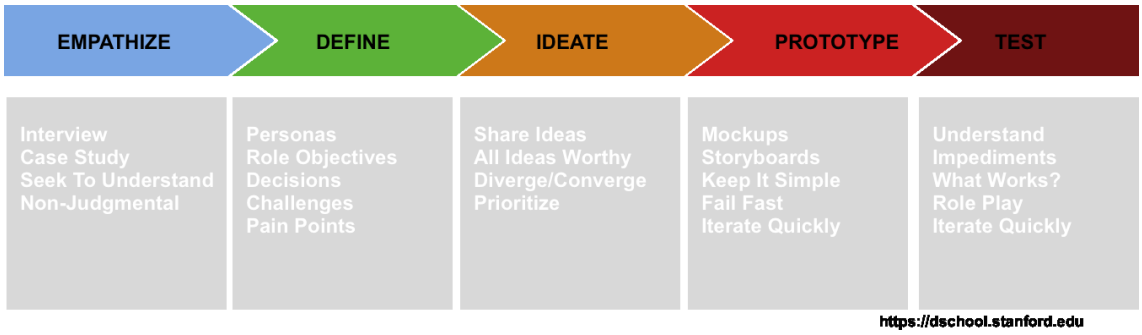

Figure 9 Human centered design process for AgriICT

The initial requirement and design will be elicited using the Human-centered design approach. Using the HCD process will provide a structured way to gather user requirements, understand the user empathy and thereby creating a detailed persona of the user. This persona will be used for further design process.

The HCD is a problem-solving approach that starts with the user end with the users. The work starts with creating an empathy map about her user we are designing for. The HCD consist of three phases. The first phase is to engage yourself with the users' lives and understand their abilities and limitations. In the second phase, we will understand what we have observed in the previous stage, identify opportunities for design and create a prototype of the solution. Finally, in the implementation phase, develop on the prototype and test it with the real user and continue the process.

As the definition of the problem statement was done in the initial state of the project, then we proceeded to empathize with the user. The location of the research team and the users were spread in two different continents during the design phase of the project. So, the

research team decided to create the empathy map and user design with the existing research and literature on the same and similar users. It was agreed the project will proceed with the User study of the existing research and the prototype in the later stage of the project will be tested with the real user.

The research proceeded with a literature review on UI from illiterate users, Farming practices in India, State of farmers in developing country, agricultural supply chain process, crowdsourcing agriculture and agricultural market practices in India. Our research extensively used earlier research work done by some prominent researchers like Hendrik Knoche, Indrani Medhi and researchers conducted by Vodafone research and Microsoft research institute. Prominent researchers include M-Pesa, connected farming in India by Vodafone India, COCO -connect online -connect offline and Crowdsourcing Application for Agricultural Development in Africa to name a few. These reviews helped us in creating a deep picture of our user. Thought the literature fell short of creating a broad picture of users from various regions in the world (farmers vary with different regions due to many unique challenges they face), It created a deeper overall characteristic that is common to farmers from different regions of the world. We created our initial persona of the user with this available information.

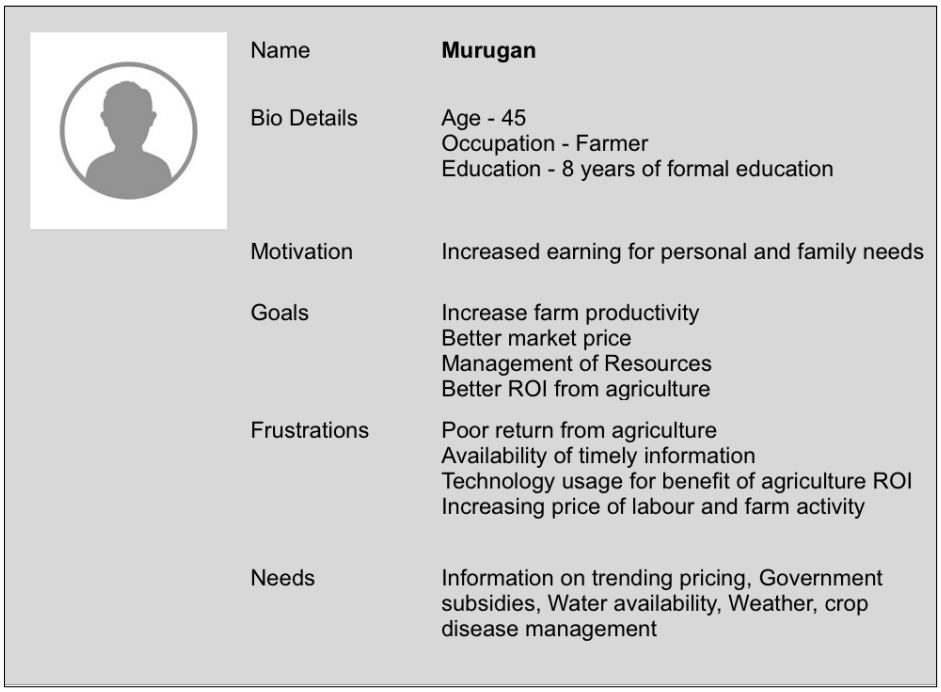

Figure 10 Persona designed from literature review

Given the complexity of the design and the diverse nature of the users, the project will benefit from the LEAN design philosophy. It is near impossible to include all the necessary features for a successful implementation. The requirements of the users also keep changing along with their interaction life cycle with the project. The learning experience

users will have with AgriICT will also improve the efficiency with which the users perform their task. Taking these factors into consideration, it will be beneficial and effective to follow a LEAN start up process. The idea is to create an MVP (minimum viable product) initially. The initial MVP will be tested with the user. This will provide us with the opportunity to validate ideas and features. The design ideas that are validated will be included in the subsequent sprints to be developed up on while the not so popular ideas will be discarded.

6.1.2 LEAN Development Process

The reason for choosing LEAN process for developing AgriICT is to create maximum value to the Users with fewer resource. The LEAN development process understands the value the development is trying to create and focuses the development efforts in continually improving that value. Through this approach we can maximize the customer value with minimum resources available at our disposal. Managing a potentially huge project like AgriICT will be easier through the LEAN process. To achieve that objective, the LEAN process specifies three P's which are purpose, process and people [43].

Purpose signifies what user problem will the AgriICT service solve to achieve its own objective. The process is how the AgriICT will assess each major value, too make sure each step is valuable with regard to the bigger problem. Finally, People is how will the service ensure every important process has some one responsible for continually evaluating the value steam of the service. This is typically important for a self-sustaining ICT design. As mentioned in the literature review, any ICT project can lose its original purpose due to miss-use of the system by participants (creating spam messages or using it for unintended purpose), using the system for short term benefits or some other harmful purposes.

The implementation of LEAN process can be easily governed by following the 5 steps mentioned here. They are [44]

1. Specifying the value from the User's stand point
2. Identifying the steps in the value stream and elimination the steps that do not create value
3. Closely align the value in tight sequence so the service will reach the user smoothly
4. As the slow is created, let the User get his value from the service
5. By now the value stream is evident, persist in the service activity and eliminate the unnecessary feature.

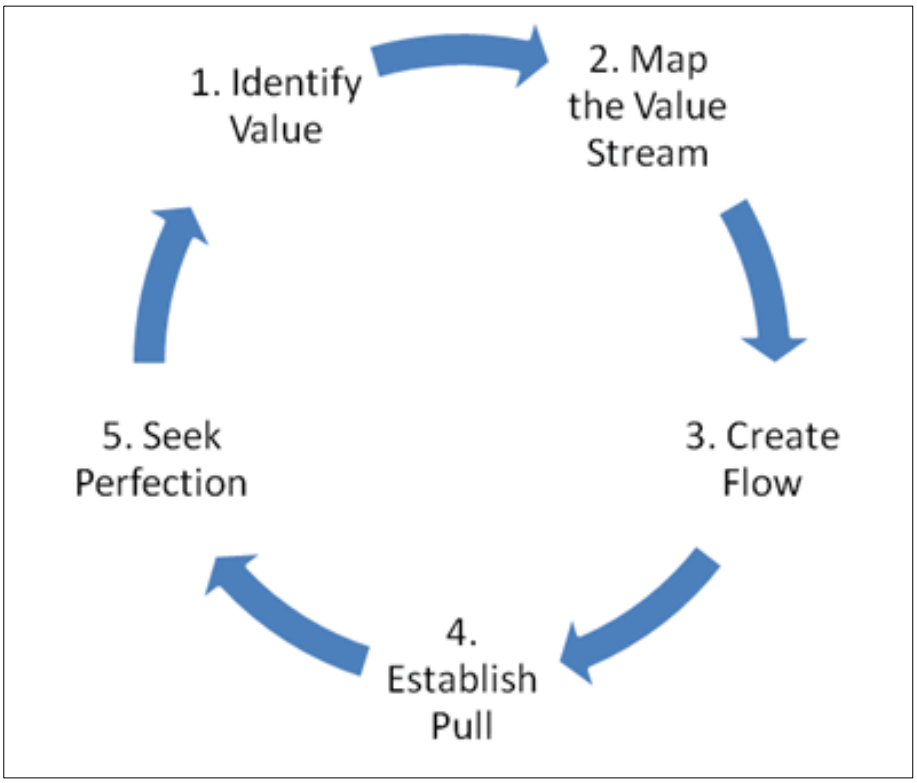

Figure 11 LEAN process for AgriICT [44]

By following this approach, the AgriICT service can build on its initial design and build value as the service matures.

6.2 Design Guidelines

Contrary to the popular belief, Illiterate users do own high-end mobile phones including iPhone. They do consider owning a high-end smartphone as a symbol of status. However, literate users employ a certain strategy to use a smartphone and navigate the UI of their mobile phone. For example, they use diary to store a telephone number, use a different color for different users, business cards and even different spatial locations in the home for different contacts. Additionally, researchers showed that the semi and illiterate users did not exhibit marked the difference in the speed of doing tasks with their mobile phone. They often employ a method call as “Rote learning”. Rote learning can be best described by quoting a user response “I click the down button twice and click the green button”. This way they traverse various screens of the mobile. This may be useful on certain occasions, but is not guaranteed to be successful. To memorize these steps with the assistance of a friend or family member who can operate a device. They learn the step by repeating it again and again. They also use icons as landmarks and use the length and font size of the text to orient themselves in the interface. So, intelligent use of the icons is beneficial in designing a UI.

To read a text message, they often ask the assistance of their close friends to read a message. They have developed a heuristic method to judge a new message. For example, if a message is too long or contains a lot of numerical character, they classify it as a spam. Sometimes, if they get a text-only message they call the sender directly. To access the contact list, they mostly use the recently dialed list. Some users also use messages with contact number as a place to access some contacts. However, the users showed general aversion to devices that are stigmatized as devices for illiterate as no one likes to be associated with illiterates. So, a recognizable association of a device or an application as built for illiterates does not serve the purpose as no one wants to be identified as illiterate.

Illiteracy has been just one problem while the illiterate users interact with technology. Some of the other issues include cognitive difficulties, cultural effects, exposure, experience, technology intimidation, collaboration, motivation, pricing and social status.

After careful consideration of the user following design, recommendations should be considered while designing for non-literate users.

Following are some of the design considerations gathered from the literature review for the purposes of designing AgriICT. Any service or product that is designed for the poor or illiterate should try to avoid stigmatizing the service. People avoid associating themselves with the words like "poor" or "illiterate". This is due to fear of social isolation and presumed ill-treatment. So, designers should avoid over uses of the said terms for their service. it is a good practice to provide audio feedback "on demand" along with the texts in the UI. But the repeated use of audio can disturb the task flow. The users will use the audio only when they are in doubt about the texts. It is good to provide speech to text for message composition in the UI. The users can use this feature to create test contents. Also provide audio feedbacks in the maps UI for textual contents like place and location names. Associate contacts and phone book entries with colors, so it can be used as additional reference for memorability. Users who has difficulty reading name can associate particulate contact with the colour used to store it. Augment menus with voice notes, and doodles to enhance accessibility. It is a good practice to include child-safe mode and advanced undo features. Providing "undo" features will reassure users that they can call back any mistakes they might commit in the interface. This will allow the users to operate the interface more boldly. Finally provide clear distinction and visual hierarchy, the users can easily sort through the contents.

Crowdsourcing information: The thesis relies heavily on characters borrowed from crowdsourcing. “Crowdsourcing is defined as sourcing of information from a group of people in response to an open call, request for specific information, or for an exchange organized by a governing body” [45]. It often means outsourcing a piece of the task done by local workers to a large group of disconnected people. For a crowdsourcing service to be successful it should be having the following characteristics. They include defined role and task to be done by a group. Secondly, does the participant have the capability and

technology to participate in the service and finally the monitory incentive or other motivation for the crowd to participate in the service. Utilizing crowdsourcing leverage the use of accumulated knowledge of a group of people for the benefit of all the participants of the service. The contributor of the information will also benefit eventually from the service. It enables the participant to get a large quantity of data from the diverse source. The crowdsourcing is particularly beneficial to smallholders by increasing farmer access to information, market access, integrated farming, tracking pests' outbreaks, and weather alerts to name a few.

6.3 Initial Prototype

Figure 12 Initial prototype wireframe

Features planed for AgriICT

AgriICT will include following features after careful consideration of the objective and perceived requirement of the agricultural users. These features will be helpful in assisting the farmers in their day to day agricultural tasks.

Trade – AgriICT will include available agricultural tools for sales. The farmers can also buy and sell tools using the service.

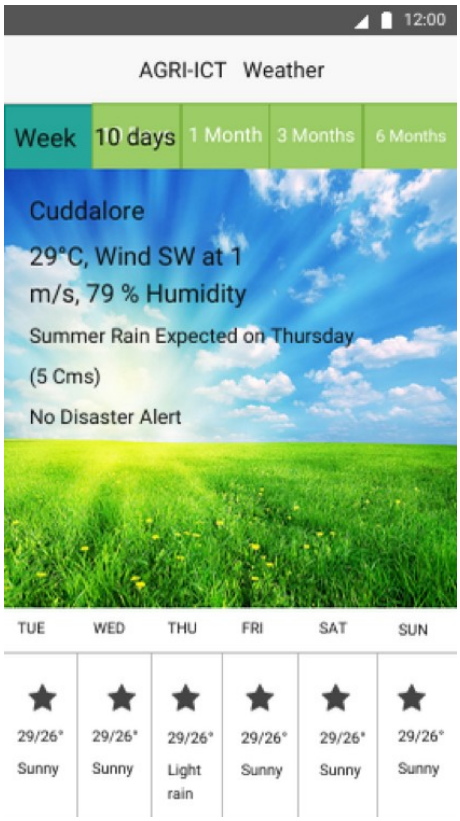

Figure 13 Weather alerts

Weather – Weather service will provide weather details and alerts on impending conditions. This will enable farmers to plan their activity better and mitigate risks.

Technology – This planned section will provide information on latest technology developments in the field of agriculture

Government Information – This section will provide latest information on government announcements and schemes.

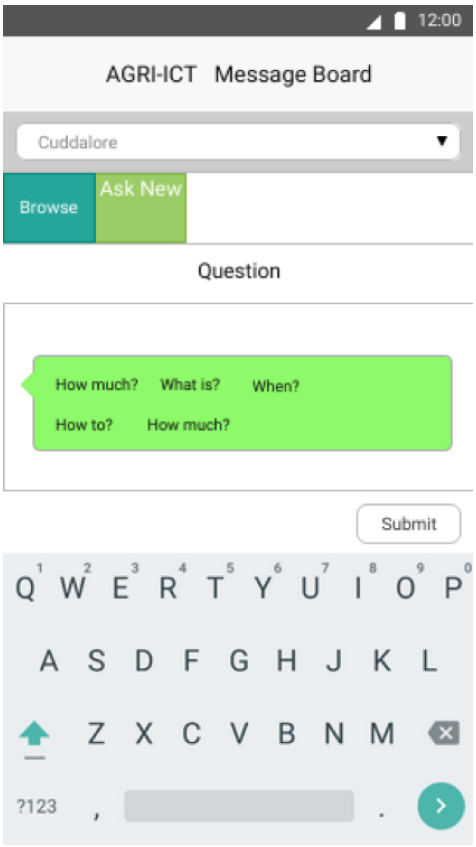

Figure 14 Message board

Message board – Message board will facilitate communication between two or more participants. This feature will be crowdsourced as any question raised here will be answered by many people.

Expense tracker – This feature will enable farmers to track their expenses for they make during a cultivation season. This will help them calculate the capital expenses and running expenses. Knowing the expenses will let the farmers calculate the exact cost of the produce.

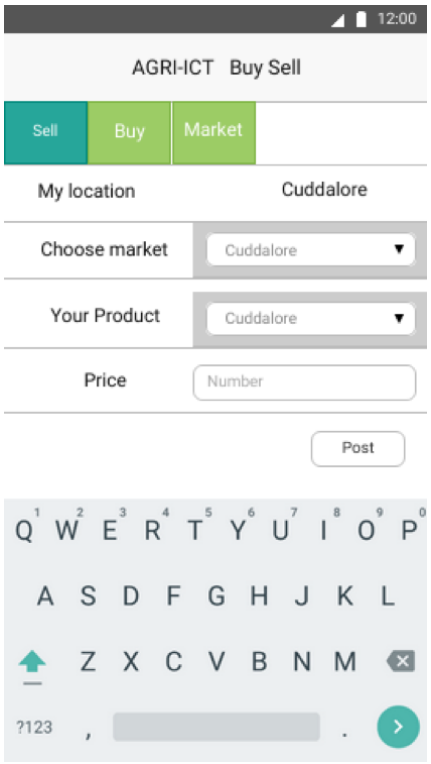

Figure 15 Market price

Market price – This section will inform farmers of the trending price of agricultural produce in different markets near the user's location. The user can also select a location to know price trends in the selected location.

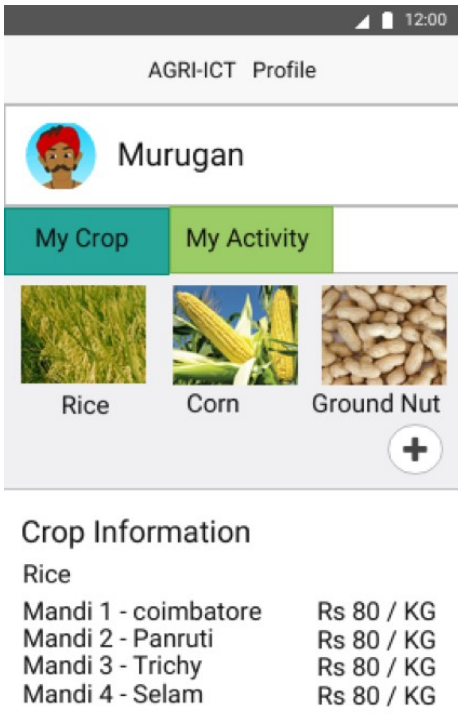

Figure 16 Subscriber view

Mandi Information – Like the market rice information mandi information shows the cost involved in price offered in wholesale markets and other costs involved in storing and transacting the agricultural produce.

Crop Suggestion – This feature suggest crops to be considered for the upcoming season the can provide optimum returns. This would be the main value provided by AgriICT.

7. CASE STUDY

This Chapter describes the user evaluation methods employed for the purposes of validating the user perspective about the proposed AgriICT design solution. The section describes the case study done in the field for this purpose. It explains the objectives of the study, how the study was conducted, recruiting the participants and finally describes the result of the user evaluation.

7.1 Study Objective

The primary objective of the study is to get a better understanding of the primary users in their socio-cultural and location settings. A questionnaire was designed to elicit information regarding the same (Reference). The secondary objective of the case study is to evaluate the initial User interface designed with the design recommendations gathered from the literature review. This was achieved by conducting a user-testing on the low-fidelity prototype as well as using MyRML application described in the competitor analysis section of this thesis.

Following are some of the objectives of the Case study was designed to find answers. The objectives included ethnographic and functional questions to understand the potential and limitation of the intended users.

Educational background – Understanding the educational background and general literary capacity of the users will help us in designing the service better.

Agricultural practices – How are the users conducting their everyday activity and how are they currently planning their activities. Do they have any process they follow every year? This is necessary to understand so as to plan where AgriICT can find in the process.

Agricultural marketing – How are they marketing their agricultural produce. This is a location-specific question as the marketing procedures can differ from various regions. How is the finding the best possible market for their procedure?

Technology proficiency – What are the mobile devices the users are currently using. How fluent are they in using a smartphone? Answering this question is essential because AgriICT primarily is an application that will be running on an Android device. So, it is essential to find how comfortable are the users in using an Android device.

How are the using mobile technology – The thesis wanted to know the internet habit of the users and how are they using their mobile phone for accessing the internet. The question involves finding out if the users already know about the mobile internet, do they use social media and messaging services like WhatsApp. If we find out that they are already

using mobile phones for this purpose, we can extend some of the design principles of social media interface and reduce the learning curve of effectively using AgriICT.

Sourcing Information currently – The case study requires to find out how farmers are currently sourcing information on market price, treatment of diseases and new farm practices. It is important to know the source of the information and the reliability. It is also important to know if they are getting correct and update information.

User's expectation from AgriICT – Understanding the user expectation on AgriICT is essential to know if we are developing a service that creates value for the user. Understanding the user needs and matching the user expectation is important to create any successful application.

Willingness to participate in crowdsourcing – It is important to understand what motivates users to participate in a crowdsourced information sharing platform like AgriICT. The motivation and the reward expectation of the users are necessary for their active participation in the service.

Use of crop suggestion – Also it is necessary to understand how the farmers are choosing their crops for a plantation cycle. This understanding will give a better service of suggesting crops, so the farmers can benefit from crop suggestion made through AgriICT. This knowledge will help us create a better service.

Usefulness of the perceived system – Finally, we have to understand if the farmers require a crowdsourced service like AgriICT. IT is a futile exercise to design and develop a system that has no demand from the intended users. So, to avoid such situations it is important to understand if the farmers really require a system which enables them to communicate and co-operate among themselves with their development as well as the community at large.

Apart from the above-mentioned objectives, it is also necessary to understand the user's proficiency in using smartphones. So, a user testing to understand the user's proficiency with the smartphone was conducted along with the case study.

7.2 Case study design

The case study was designed to find out the details defined in the study objective. A questionnaire for an interview was designed to elicit information from the Users while considering the social factors relating to the Users.

The case study planned to utilize semi-structured interview to facilitate open discussions with the Users. The interview includes set of pre-designed questions to explore predetermined themes of the case study objective. Also, the designed questions will lead to further discussion on the defined topics.

Preliminary questions were related to the users educational and family background. It was also necessary to know if any of the family members of the User is versed in technology usage. This is enquired to find out if any other family member of the User is fluent in technology. If that is the case, that member can help User create content and consume data using AgriICT. More often, the younger generation in an average farming family are introduced to technology and can use social media, messaging services like WhatsApp and media services like YouTube [46]. This can be an important value addition to the farming community. This will facilitate the participation of the next generation into the farming activity, thereby the younger generation can contribute to the income of the family.

It was important not to embarrass the Users asking them about their educational background. As a researcher, it is important to heed the feeling of the Users. So, instead of asking for the educational qualification directly to the Users, we chose to ask their reading habits and what are the magazines or publications the read regularly.

Subsequently, Questions were focused on the technology usage of the Users. We wanted to find out which mobile phone models they were using currently. How often they use it, how do they access their mobile phones, messaging habits and internet usage from mobile phones? If we find out they are typing messages on their mobile phone, they can extend this knowledge in using AgriICT. And if they use smartphones and more specifically, some mobile application, they would find it easier to adapt to AgriICT. We also tried to find out how they are using their mobile phones for their agricultural activity. This is necessary to identify if they are already being aware of the positives they can achieve using mobile technology.

Thirdly, we tried to find out if they are really small farmers who own less than two acres of land. A farmer who owns 5 acres of land is necessary to pay taxes for his agricultural produce and have more resources at their disposal. Also, the primary target of this thesis is small farmers who own less than 2 acres of land who have relatively fewer resources at their disposal. It is culturally sensitive to ask a person about his wealth holdings, so we decided to ask what has planted in his land. We assumed, by this way, the User will total area of cultivated and uncultivated land and what he is cultivating on his farm. This will paint a brief picture of the amount of land he owns and what he is cultivating. This question will lead us to understand how he is marketing his agricultural produce.

We tried to understand if the users are actively seeking to find the best market or he is selling for the minimum support price to a nearby market. This will help us know if AgriICT can add value to the farmers in finding better markets where they can get a better return on investment for their produce.

Fourth, we tried to understand the role of middlemen in the supply chain. We questioned the users about the middle men’s existence and if the farmers are selling their produce to

middlemen. We also wanted to know what the users themselves are feeling the middleman in the agricultural supply chain and is there a requirement to avoid middlemen through AgriICT service.

Finally, the questions were designed for getting details on how the farmers are getting information. The research has to understand how the farmers are getting their information and its source. What the farmers do when they want information and how they get information regarding the prices and any assistance they may require for situations they face in their farming activity. The reliability of the received information also adds value to the information. Also, we tried to understand if the farmers are co-operating their activity with other farmers in planning and marketing their products and if they are helping one another.

In Addition to the interview detailed above, the research conducted a user testing to find explore the proficiency of farmers in using a basic smartphone and to understand the limitations of the users in handling a smartphone. The plan of the user testing was to ask the user to perform certain basic tasks in a low-end smartphone.

7.3 User Test Design

The user testing was designed to understand the Users proficiency with regard to smartphone usage. As mentioned earlier, the Users were asked to perform certain basic tasks on an Android smartphone. Also, the Mid fidelity prototype of AgriICT was presented to the Users to get their preliminary feedback about the system. The tasks are related to some of the features of AgriICT. The tasks include making a call through a smartphone, opening the messaging application, use of google maps and a weather application. The purpose of the task is to see what the Users infer from the icon designs and check if they understand the iconographies of the smartphone.

Tasks for the Usability test included the following.

- Make a phone call a given number.
- Navigate to the main menu and identify messaging app
- Go to google maps and identify your current location
- Find out the weather for your location.

7.4 Recruitment and Participants

As a part of the case study, we tried to recruit participants to form the contextual settings. We tried to recruit farmers working in the field and conduct the interview and users testing. It was decided to recruit participants who are working in the agricultural fields. For this purpose, we chose Villupuram, an agricultural town and also a market center of the larger Villupuram district. A diverse variety of crops are cultivated in the town ranging

from rice, oilseeds, vegetables, sugarcane, fruits, tubers, and cereals. This town was chosen for its surrounding agricultural villages and a central agricultural market. The town is also a center for an agricultural and related activity like seed bank, fertilizer, farm pesticides and large agricultural equipment. Some more interview was conducted in Neyveli, India. It is another small industrial/agricultural town growing cash crops and oilseeds.

In order to find participants in the field, we have to go to the location during the farmers' work hours. A typical day in the Indian farms starts very early in the morning. The day's work starts at 4 AM and lasts until 12 Noon. This is mainly due to the climatic condition of the location and avoids the day heat. So, we visited the farms during the early hours of the day to recruit participants for the case study. But this way we could recruit 16 participants for the study.

7.4.1 Education details of the participants:

A total of 16 interviews was conducted among the participants from Villupuram and Neyveli. 13 participants were from Villupuram and 3 participants were from Neyveli. The participants were primarily farmers in the age group 3-68. All the participants owned farmland in the chosen locality. They owned on average from 3 acres and lower to few 20-30 cents (1 cent = 435sq feet) of agricultural land. Their primary language of communication is Tamil and 2 participants can speak Telugu. They understood only Tamil and few signboard English words.

The education level of the subjects was the basis. 4 participants had completed high school and were also employed in government jobs. One of the participants was a government bus conductor. But the others had a minimum formal education. 6 participants had 5-8 years of school education and 6 had no formal education. Some participant had taken up additional jobs like house painters and masonry works.

However, they all have one thing in common. The participants had no computer experience. They owned television and could operate machinery and some kind of display interfaces. All the participants owned a mobile phone. Only two participants used a basic smartphone. Most of the participants used basis button phones. They used their mobile phones for making and receiving calls and some time for messaging. They understood small messages from their banks and family members.

All the participants had someone in their household or neighborhood, who is educated and can operate a smartphone and computers. These traits of the participants make them suitable subject of our research, test and gather information relating to the idea of AgriICT.

7.5 Case study result

Education – 6 participants had no formal education and faced difficulty reading and writing in their mother tongue. Rest of the 10 participants could read the newspaper. The participants with no formal education over their limitation by memorizing the work structure of frequently used words. They could identify for example their hometown name, nearby places, their name and family members names and other road signs like for example stop, police railway station, bus stops. The participants with minimal education used mobile phones frequently and understood the menus and the context.

Technology proficiency – They seem to remember the physical location of the menu or the number of clicks (like press main and press down button 5 times to access phonebook) to access what they want. They also used "Recently dialed list" or "Received call" more often since it is easier. They also saved contacts by copying the details from a written contact information. Irrespective of the education level all the participants had a small diary or pieces of paper with them and used it as a memory aid. They also associated a person with the spatial location of that person's contact number in their memory aid. They also said they can identify a contact with the color of the ink they used to write down that contact information (The house painter has written his contractors number in red ink).

Technology Usage – All the participant owned television and regularly watched News broadcast and had multiple cable channels. They had someone in the family who used the internet and understood the concept of messaging and multimedia sharing. They remarked that their kids spend a lot of time on the internet and the participants themselves are not interested in using the internet. They used the help of net cafes and browsing centers to book railway tickets, open bank accounts and get government documents/registrations. They used their mobile regularly for getting information related to their agricultural activity. For example, they called the marketers and shopkeepers to get related information.

Agricultural practice – Majority of the participants were growing the same crop throughout the year. They informed that the specific region is suitable for rice and so they grow only rice. They call it "Nanjai" land also called wetland, optimal for growing rice. A year can have a cycle of harvest lasting for 9 months and the rest of the year they grow cattle fodder. They refer to a cycle of the plantation as "pattam". They harvest the crops using hired harvesters and equipment. The sorting is done on-site. The sell the rice to government societies located in towns and villages and to government stipulated minimum-support price. Minimum-support price (MSP) for a popular rice[47] quantity of rice is Rs.1470 [48]. A participant who owns 2 acres of land produce 30-35 bags of rice (1 bag= 90kg of rice – without dehusking) and sell it for Rs.46000 (for the MSP). He gets a profit of Rs.15000 after all the expenditure for a year. This implies that the farmer sells the rice for Rs.14/Kg and after processing, the rice reaches the consumer from Rs.45 to Rs.80. The participants also get the fertilizer and pesticides from the society. The societies

also assist farmers in regard to any crop diseases. Also, APMC stipulates that the all farm produce through government stipulated market auction.

However, Neyveli is a dry land called as “punjai” and more suitable for fruits and vegetables. The participants from Neyveli grow sugarcane and sell them to the sugar factories near than, primarily to Parry’s sugar, a popular private company in India. Again, they sell the sugarcane for MSP. Another participant from Neyveli grow ground nuts and other seasonal crops and sell it in the local market.

Sourcing information – All the participants get information from the newspapers and television. However, this information is outdated is irrelevant to their location at any given time. They use the information as reference points rather than actual values. Also, they use local societies to gather and share information. They have to physically go to the location of the societies to get first-hand information regarding on trends. They do get outdated information at times. The participants indicated that most often they get information from their neighbors, friends and family members from a different location. In case of the different physical location, they use their mobile phones to call their acquaintance. Local places of gathering like a temple, bus stop, and tea shops also are valuable places from where the farmers can get information.

Middleman – The rice cultivators do not seem much bothered by the middlemen. They see middlemen as overmuch part of the eco-system. Some participants also mentioned that some of the middlemen are also farmers themselves ideally holding some land. This is due to the fact most of the rice cultivators market their produce to the government stipulated societies to pre-accepted price. However, Participants who hold dry land and produce a variety of crops are more dependent on the middlemen. They informed that due to APMC stipulation, they are forced to sell their products to government-specified markets and through auction. Most often the auctioneers are middlemen and manipulate the price of the products on demand supply. This was the middleman's control the demand-supply and the market price. During surplus production. The middleman procures the products for a minimum price but sell to the consumers it without much price variation. Vice versa when the supply is lean, they procure the crops at a bit higher price and sell it extremely high price. This made participants frustrated as the middlemen benefit most from the supply chain.

Crowdsourcing – The participants indicated their willingness to participate in AgriICT and share information with other farmers. They indicated that they will benefit from the information they receive and share, as most often they lose trading opportunity due to lack of information beforehand. This will motivate the farmers to use AgriICT service.

7.5.1 Expectation from AgriICT

All the participants were excited when they were told about the idea of AgriICT. They participant excepted a solution for reducing the Arbitrary price policy of the existing market. They wanted to understand how the price of their crops raise are fall and wanted to know the trend ahead of the harvest time. The wastage calculation also varies from the various market. The participant wanted to know the wastage percentage deducted from a particular market or society and wanted to know how nearby markets are doing at that time before they transport their products to that market.

Most of the time the farmers decide on a crop, choose a new crop from word of mouth or a new method of farming (like organic farming). For example, 1 Participant set up a mushroom farming set up on his farm from word of mouth and was not aware of how to market the mushrooms and the price point for that variety of mushroom. Due to delay in information on marketing, he suffered initial loss. The participant wanted an assistant in knowing “what to do next”. The participants mentioned that they need a service where they can get ideas on what to do next and plan their activities accordingly. The participants also were eager to know about new agricultural trends and developments that can impact their earning capacity. They wanted information on agriculture-related activity like horticulture, beekeeping, and organic farming techniques.

The weather is also a gray area when planning their actions. The participant's Untimely showers negatively affect the yield and so it would improve the situation if they get alerts for off-seasonal rains. Since Villupuram depend on groundwater for much of its agricultural needs, they did not worry about water availability in dams. But the participants informed the research that the delta regions in the southern part of the state will expect information of water release dates from the dams and reservoirs.

All the participant informed that they depend on government loans and loan weaver schemes and they wanted information on the same. They wanted any information service to provide alerts to the farmers on government schemes and prospective agricultural loan information. All they wanted alerts on the government schemes as early as possible, so they don’t miss possible enrollment dates.

The general feeling among all the participants was a sense of abandonment. They felt they were abandoned by the central, state government and public and private organizations. The mood was they were left to fend for themselves. This was due to the fact that the central government was employing stringent loan recovery methods, deficient rainfall, unsatisfactory minimum-support price and lack of support for agricultural activities from the state government. The farmers were eager to participate in a crowdsourcing information system, so they can help themselves.

7.5.2 General Feedback:

Most of the participants were hesitant in the beginning to participate the study. This was because of the assumption that the research was conducted by the governmental organization and the associated stigma. One it was clearly indicated to the participants that the research was part of a private individual study, they were eager to participate. Some expressed their gratitude for the fact that someone was researching to improve their situation. So, participants were still skeptical as the ask “what is it to me?”. Once the purpose of the research was explained to them, they participated eagerly.

Questions about age, education and land ownership were also difficult to handle. The participants were hesitant to provide details of their age and education details. They provided approximate data for age-related information. Instead of asking their educational details, we tried to inquire about their reading habits, what is their preferred newspaper etc. We expanded the questions based on the participant's response.

7.6 User Testing

Following the interview, the research conducted the user testing to understand the limitations of the participant in using the Android smartphone. 8 participants refused to participate in the user testing. The participants with no formal education denied taking part in the user test. They also mentioned that they might break the device accidentally or cause malfunction. There was a general aversion to technology with illiterate participants. They were also concerned that they might smudge the mobile phone because their hands were soiled.

As mentioned earlier, only 8 participants were ready for user testing. The background details of the test participants are mentioned in the below table.

Table 1 - Background information on the Participants for user testing

	Age	Gender	Education	Occupation
Participant 1	52	M	High School	Farmer/ Public transport Conductor
Participant 2	50	M	ITI (Technical training)	Farmer/ Home Guard
Participant 3	43	M	3 years	Farmer
Participant 4	60	M	4 years	Farmer
Participant 5	68	M	5 years	Farmer
Participant 6	37	M	High school	Farmer/ Harvester Operator
Participant 7	24	M	High school	Farmer/ Bank Peon
Participant 8	38	M	4 years	Farmer/ Painter

The tasks were decided to find out the basic proficiency of the participants in using smartphones. The tasks also mirrored some of the planned features of AgriICT. For example, the messaging task was designed to find out if the participants can navigate the smartphone menu and what the perception of the icon design used in a common smartphone. This, we believe, can give us details on how to design icons for AgriICT and the users can understand it. The user was asked to perform a task on google maps and a weather application. Both the application part of the planned design of AgriICT. So, the said task was included to find how the users understand the application

Table 2 - Tasks used in the User Test

Task 1: Make a call to the number "962*******". Disconnect and make another call to a contact from phone book
Task 2: Navigate to the main menu and identify messaging app
Task 3: Go to google maps and identify your current location
Task 4: Find out the weather -Temperature of your location.

7.6.1 Test Result

The test gave valuable insights into the participant's proficiency in using a smartphone. Only a couple of the participants had prior experience using a smartphone, while the rest used touch-based phones and struggled initially to operate smartphones fluently. However, the all the participants reported that they have used smartphones of their friends or family members.

All 8-participant succeeded in the first task. They were able to dial a number and call or select a number from the recent call list. They understood the menu options well and negotiated the menus in the dial menu.

The participants struggled a bit to understand the messaging service. They instead referred it as “SMS”, from the context of their touch phones. Once they understood the term, they seem to have the contextual understanding and searched it in the main menu. The only perceived difficulty was the clutter of the main screen with the wide collection of menu items and applications. The participants demonstrated that they have a good understanding of icons and were able to distinguish different icons and their functionalities.

3 participants easily identified the google map application and had prior experience of using the application. They remarked that it is data expensive and asked if it is ok to open the application. Two participants were able to find out the map application will little assistance. On asking that what each menu icon’s functionality they arrived at the map application. They understood the map image in the icon. 3 participants did not understand the context and did not know what they have to do to arrive at map application.

The weather application seems to be a surprise to the participants. The majority of the participants was surprised to know they can find out about the weather though smartphones. Only one participant who uses a smartphone found the temperature of the current location. That participant also reported that he has never used weather application for his personal planning or agricultural activity, but it will be good to use the weather application. Two participants who understood the context of menus succeeded in the task with some help. 5 participants could not complete the task after assistance.

They had knowledge of using smartphones as someone near them uses a smartphone. Overall the users seemed to understand the context of menus and submenus or the understood after some help. So, we can extend the same finding to AgriICT design and assume that the target users will find it easy to use and learnable with some initial training. The knowledge that using AgriICT have potential to increase their revenue will motivate them to learn using AgriICT.

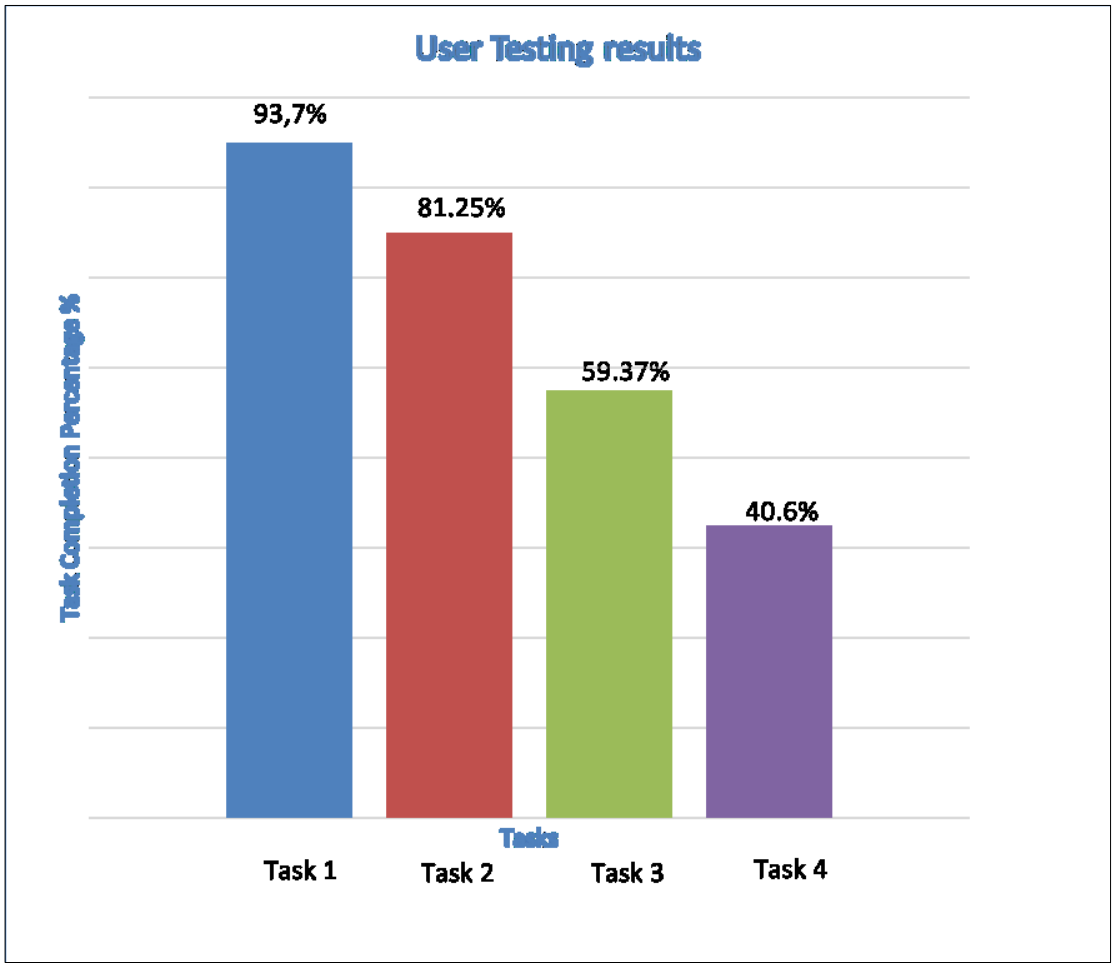

Figure 17 Usability test result

7.7 Discussion

The case study indicates the need for information-sharing platform for the agricultural sector in India. A crowdsourced application will eliminate some of the cost involved in maintaining a similar service, for example, employees required for creating and maintaining content. By doing this the application can be provided cost-free for the end user. By creating the service, the user can control his activities better and create long-term relationship with other farmers and marketers.

Crop suggestion is one of the cores of AgriICT and will use inputs from the user, weather and crop price trends to suggest farmers what he has to plane in the upcoming seasons to get maximum profit. This was also one of the primary expectation of the user. They indicated that they want to know what to do next when they are nearing a harvest season. The case study also indicated the users are willing to share, receive and use that information.

The research found that the market price of commodities varies from one location to another and from one season to an outer. It pays to have the awareness of the market price and there is no platform to provide information on demand. Some of the applications that

provide market price information are costly and outdated. So, the need for such a platform is evident and AgriICT will be the service to fill the gap.

The research also showed the lack of awareness from the uses in using mobile technology for their benefit. The farmers were unaware of using the weather application to their benefit. This indicates that need for providing alert service do they do not miss the benefits offered by the mobile technology. Providing alerts on impending off-seasonal rain showers, gale force winds, new insect infestation, and epidemic will reduce or better eliminate farmers' losses. This featured can be a potential lifesaver.

AgriICT hopes to create better-educated farmers and improve their knowledge about the whole sector as a whole. The application has the potential to increase the collective knowledge of the community and can create an efficient society at large.

Finally, the research has removed the primary risk for a crowdsourcing design, which is the motivation of users to contribute information and help one another. The research outlined that the participants are more than willing to help one another. AgriICT expands the limitation of space and distance and creates one big farming community by connecting to previously unknown farmers separated by distance.

What are the risks involved in achieving the planned AgriICT service now?

As evident from the field visits, there are some hindrances in realizing the plan of establishing AgriICT services. Some of them include user proficiency in using smartphones, availability of a smartphone for a small farmer, internet infrastructure at the user end. Some of the challenges at the development end includes technology challenges in developing a complex suggestion system, funding for developing and sustaining the application.

At present, the targeted users of the system lag in their capacity to operate a standard Android smartphone. However, given the ever-increasing popularity of smartphones, we can expect the users to operate the smartphones soon. All the participants in the case study had someone close to them own a smartphone. AgriICT can benefit from this fact that the user can get help from their friends and family. Give the simple design, the users can learn to operate AgriICT themselves. In case of the illiterate users, they can get help from their contacts in village centers, temples and shops where they meet other people form their village.

The internet network penetration is also in the rise and the competitive environment among the mobile service providers are decreasing the cost of internet and the speed is getting better. The internet scenario is getting better by the day and villages are connected to the network. AgriICT can benefit from this scenario.

AgriICT can benefit from machine learning and pattern recognition for some of the planned features like crop suggestion and activity planner. The full potential of AgriICT can be realized when it is used by a huge user base spread across different regions of the country. Funding to develop this complex system will be critical. Any further research on this topic will have to sort this issue to proceed further.

8. CONCLUSION

8.1 Significance of the research

Working on this thesis research created the opportunity to meet farmers and learn what it takes to bring food to our table. Meet the farmers in the filed provides first-hand information on the farming process and the problems faced by the agricultural sector. This thesis work recorded some of the most important issues and by-no-means comprehensive. There are many more issues the agricultural sector faces today. For example, this thesis does not talk about the opportunities and challenges created by genetically modifies crops. This new phenomenon in the agricultural sector has to be explored and its impact on farmers and AgriICT should be assessed.

The features of AgriICT discussed in this work are open to scrutiny and further improvement, as the primary objective is to improve the knowledge base and earning capacity of small farmers.

8.2 Future Work

This thesis work was limited in its reach and conducted an extensive survey on just one region in India. Agricultural landscape is very diverse, and it can vary vastly from one region to another. Water availability, soil type, climate, and culture can all have an impact on the agricultural process. The process can be completely different from one region to another within a country and from different counties. However, the problems faced by small farmers can be similar and fit into some of the broader categories (like finance availability, water etc.). More exhaustive vertical and horizontal research has to be conducted across regions and countries. This can create a better picture of the problems faced by small farmers and the entire agricultural sector. This work can improve the effectiveness, efficiency, and usefulness of AgriICT and similar service.

Finally, a LEAN approach has to be followed while developing a service like AgriICT. AgriICT itself can be split based on its features. Each feature should be tested with the user and improvements to the design should be included in the further design sprints. Continuous improvement can help AgriICT achieve its objective.

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APPENDIX A: USER INTERVIEW QUESTIONS

Education level

1. What is your education level
2. How many mobile/smartphones in your family
3. How many members in your family? Their education levels?

Technology

4. What mobile phone do you use?
5. Internet usage experience?
6. Internet apps you have used?
7. Which messaging apps do you use?
8. How do you type the information?
9. Can you read and write?
10. How much land do you own?

Agriculture

11. How do you decide which crops you plant for a season?
12. How do you market the product?
13. Do you sell it to Mandies (மண்டி - Market)?
14. Do you sell it to Middleman (இடை தரகர்)?

Sourcing Information

15. What are the information you usually require relating to the farms and crops?
16. How do you get the information?
17. Is the information correct and timely?
18. How do you verify if the information is correct?
19. Do you receive wrong information?
20. Will you use your mobile to get information?
21. Do you currently use any information app (தமிழ் மொபைல் பயன்பாடு)?
22. Do you know what farmers in your district are planting? Will the information be useful to you?

Avoid using "Can" and "Do" questions.

1. What is your education level
2. Can you read and write?
3. How much land do you own?

APPENDIX B: CASE STUDY IMAGES

Figure 18 Case study Images

APPENDIX C: INITIAL PROTOTYPE

Figure 19 Login with location info

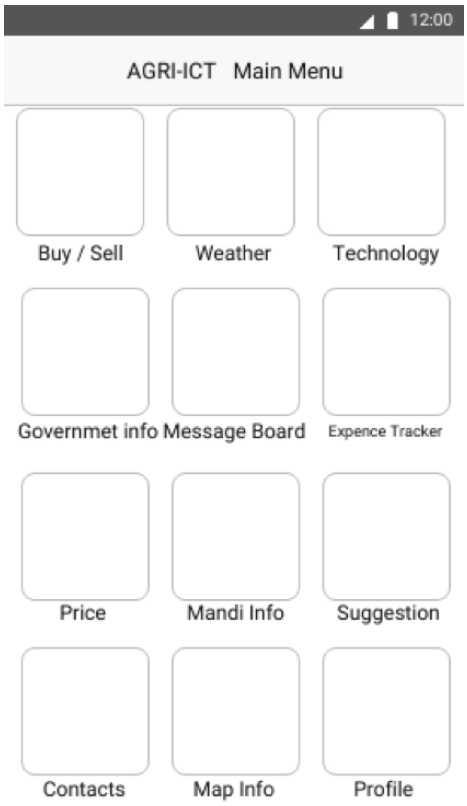

Figure 20 Main page

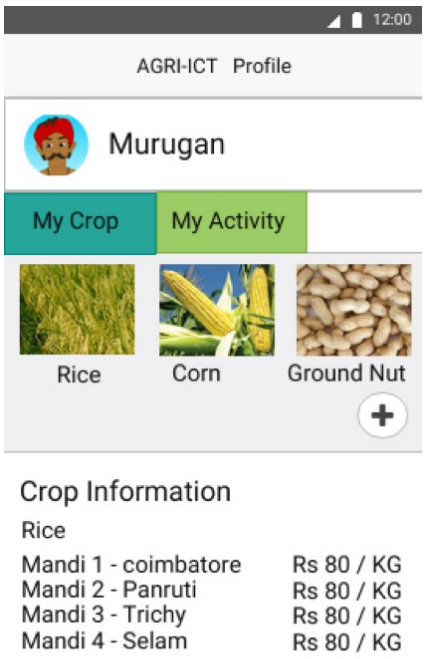

Figure 21 Subscribe view

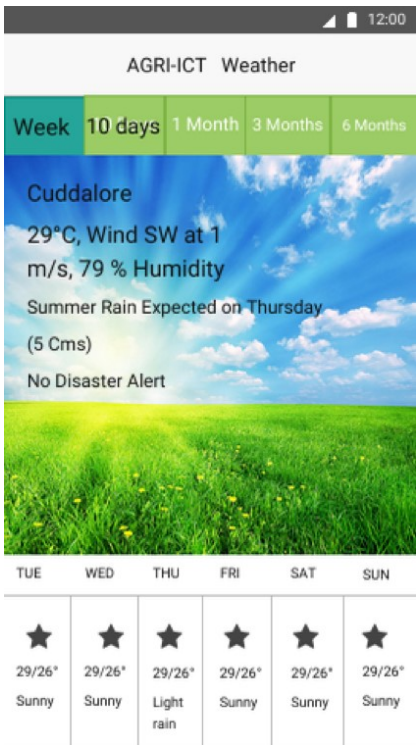

Figure 22 Weather alerts

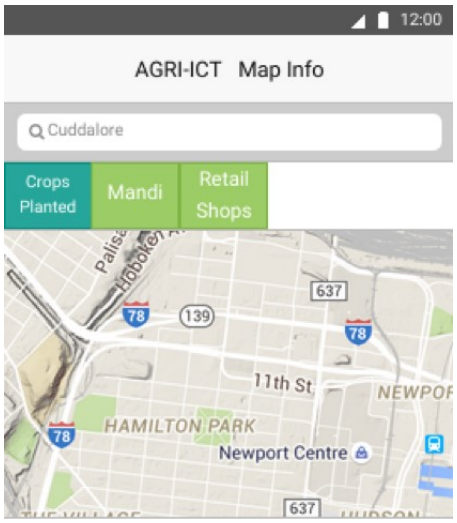

Figure 23 Crops planted near by

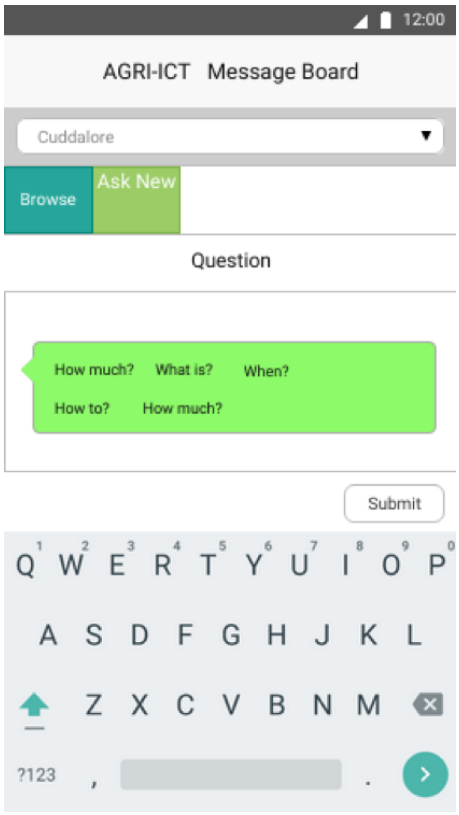

Figure 24 Message board

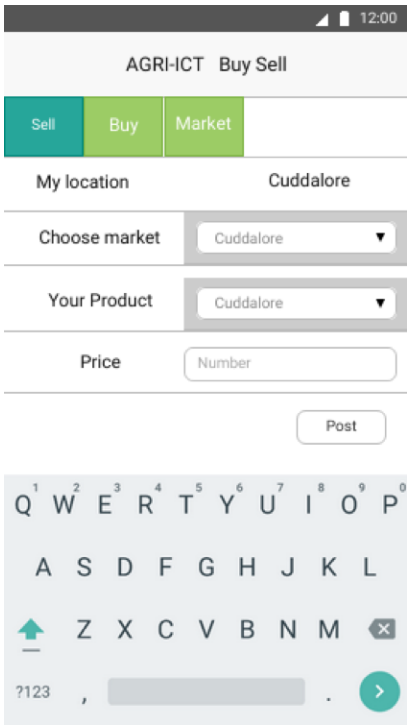

Figure 25 Market prices

Table 3 - Mid-fidelity Initial Prototype